

# Nuts & Volts

Exploring Electronics And Technology For The Hobbyist And Professional

December 1998 Vol. 19 No. 12



Merry Christmas  
from all of us at  
Nuts & Volts

U.S. \$3.50 CANADA \$4.50



12>

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BOTH SINGLE AND DUAL DRIVE MODELS AVAILABLE.

MULTIMEDIA PROCESSOR ACCELERATES DUPLICATION.

EXTERNAL SCSI-II PORT WORKS LIKE A STANDARD CD WRITER FOR CREATING CUSTOM DISKS.

TOTALLY SELF CONTAINED, NO CONNECTION TO A PC IS REQUIRED.

INTERNAL A/V HARD DRIVE STORES DISK IMAGES FOR MULTIPLE COPIES, AND CUSTOM AUDIO DISKS.

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## CD DUPE-IT!

Instantly duplicate CD-ROM disks for software distribution. Make backup copies of your favorite software on rugged, permanent media. Produce disks quickly and economically. No mastering or multimedia experience is required.

Insert your original disk and press "start." The multimedia processor quickly copies any disk to the internal A/V hard drive. Insert blank disks and make as many copies as you like. You'll produce identical, bit-for-bit duplicates. The system is totally self contained—no connection to a PC or Mac is required. Just

BUY MANUFACTURER DIRECT: \$995

**408 330-5542**

plug in the power cord and press "start"—it's that easy.

You can even make your own custom audio disks without a PC! Insert your original CD's, select the tracks you want, and CD Dupe-It will copy them to the internal hard drive. Then insert a blank CD, and you'll have a custom audio disk with just the songs you want.

With the included CD mastering software, CD Dupe-It will work overtime as your personal CD mastering system. Just attach a SCSI

cable to your PC or Mac, and you're ready to design and create your own original CD's. Similar systems used in duplication houses cost over \$10,000. Now you can easily copy disks yourself for a fraction of the price.



**CORPORATE SYSTEMS CENTER**

3310 WOODWARD AVE., SANTA CLARA, CA 95054

[WWW.CORPSYS.COM](http://WWW.CORPSYS.COM)

Software publishers—ask about our high-volume multi-drive duplication systems.

CD Dupe-It is sold and intended for backup and in-house design purposes only. Copyright laws must be observed.

...brings you a potpourri of high-tech goodies for the techno-tinkerer!  
For thirty years we have been your source for Silicon Valley exotica!

## CyberEye Color Video Camera!



- ◆ High-quality (nice looking tool) composite color camera
- ◆ 1/4 inch CCD sensor w/auto white balance control
- ◆ Resolution: NTSC 542 x 492 (250,000 pixel)
- ◆ Manual focus knob/ring, 5mm to infinity
- ◆ Power: 5.0 VDC @ 180 mA. Supply from PC or keyboard power...no external adapter needed!

HSC#17535 \$69.00

## ATX Pentium Power!

- ◆ Support for Intel Pentium 90-200, 166-200 MMX CPU's
- ◆ Also supports Cyrix/IBM 6x86 P, PR 150 & 166 CPU's
- ◆ Also supports AMD K5, and, with special VRM, K6 CPU's
- ◆ 4 PCI slots, 4 ISA slots (one shared), 16-bit stereo sound
- ◆ 4 DIMM RAM sockets, parity or non-parity, ECC, EDO, FPP
- ◆ On-board 2 x IDE, 2 x 16550 Serial ports, 1 parallel port
- ◆ New, 90-day warranty (CPU not included)



\$49.95

- ◆ ATX style Midtower case, fits above motherboard
- ◆ "Netpower" logo on front, never used, 90-day warranty

HSC# 17517 \$29.95

## Fujitsu 1 GB Drives

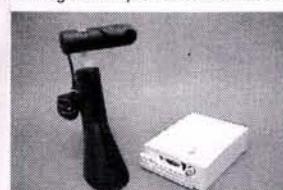
- ◆ Model #s M1606S, M2694E \$ M2932SA
- ◆ SCSI Interface - 3.5"
- ◆ Tested good and DOS formatted
- ◆ Used - w/90-day warranty!



HSC#17555 \$89.00

## Video-hacker Dream!

- ◆ Logitech Videoman Video-conference camera & interface
- ◆ These units were sold with Hewlett Packard S-700 workstations for videoconference capability
- ◆ We do not have technical data, software or manuals
- ◆ All we have is cameras with stand, and SCSI-II interface
- ◆ The camera is on a weighted stand that extends from 13" tall to over 20" tall, and has a stereo microphone
- ◆ Color camera is digital output only (not NTSC) as far as we can tell -- but who knows?
- ◆ Interface box has two SCSI-II ports on back, and a DC power input (we do not have the adapter), and on the front it has a mic. out jack, composite video out (BNC), and the connector for the camera cable.
- ◆ Note: HP and Logitech will provide no information on these



HSC#17503 \$39.95

## Drive-bay Amp & Equalizer

- ◆ Made by NEC, fits into standard 5.25" drive bay
- ◆ 5-Band equalizer has 4 channels, 6 watts RMS/channel
- ◆ 25 watts RMS total power output
- ◆ Headphone jack on front panel
- ◆ Connects to drive power connector
- ◆ No special software or drivers reqd!
- ◆ Compatible with any sound card
- ◆ Brand new, 90-day warranty

HSC#17534 \$19.95

- ◆ Also available, amplifier kit with matching speakers
- ◆ Same amplifier unit as above
- ◆ NEC Speakers are 11" tall, 4.5" wide
- ◆ Speakers have 4" 40-watt woofer, 1" dome tweeter
- ◆ Includes all cables, hookup accessories
- ◆ New in plain brown box, 90-day warranty



\$39.95

## PC Power Supplies

- ◆ ATX-type perfect for use with case, motherboard at left
- ◆ ATX supplies have 5V @ 25A as well as 3.3V @ 15A
- ◆ Our XTC312 comes with a 1-year warranty!



#17316 200 Watt Std PC \$17.50  
#XTC312 250 Watt ATX \$39.95

## RAID Server Chassis

- ◆ Trimm H420 Super Server rack-mount chassis will accommodate a high-end multiprocessor system board with a PCI RAID controller.
- ◆ Slots for eight RAID drives on removable slides
- ◆ Space for two CD-ROM or tape drives
- ◆ Three hot-swappable power supplies (300W) included
- ◆ Environmental processor and LCD display
- ◆ Supports ATX motherboard (not included)
- ◆ Can also accommodate Alpha or SPARC system boards
- ◆ Three 95 CFM fans and one 17 CFM blower
- ◆ Measures 17.75" high, 19" wide, 17" deep
- ◆ New in box, with rack slides, 90-day warranty



\$395.00

## Corel Office Professional 7

- ◆ Great Software Bundle -- Amazing Value!
- ◆ Includes Corel WordPerfect 7, Corel Quattro Pro 7, Paradox 7, Corel Presentations 7, CorelDRAW 6, CorelFLOW 3, Sidekick 95, Netscape Navigator, Dash board 95, 1000 fonts, 10000 clip-art images, more!
- ◆ For Windows 95, Windows NT 3.51 and Windows NT 4.0
- ◆ Distributed on CD-ROMs, with hefty manual pack
- ◆ New, shrink-wrapped in box, 90-day warranty

HSC#80436 \$47.50

## PCI-Bus 56K Modem!

- ◆ Genica PCI-Bus 56K Modem at unheard-of price!
- ◆ Data, FAX, voice, full V.90 compatibility
- ◆ Voice from handset
- ◆ Windows 95/98 or NT only (Not Win 3.1 compatible)
- ◆ Uses latest Lucent chipset, comes with Lucent drivers
- ◆ New retail box, with Trio application software on CD
- ◆ 90-Day Warranty

HSC#17532



\$39.95

## FM Tuner for your PC!

- ◆ Listen to FM radio while using your computer!
- ◆ Set up to 24 programmable stations
- ◆ Even works as an alarm clock (sorry, no snooze button!)
- ◆ Compatible with DOS/Windows/Win95/Win98
- ◆ ISA-bus card, receives from 87.5 to 108 MHz
- ◆ New OEM pack with antenna, audio cable, software, set-up guide -- works in combination with your sound card.
- ◆ 90-day warranty

HSC#17533

\$12.50

## 1.0 GB IDE Hard Drive

- ◆ Model P1000-2AF by JTS
- ◆ 1942 Cyl. 16 Hd. 63 Sec.
- ◆ Very thin -- only 5/8" High!
- ◆ Each drive fully tested and DOS formatted
- ◆ HSC 90-day warranty



\$49.00

## PCMCIA Sound Card!

Media Vision PCMCIA Sound Card

- ◆ Great for Portables, Laptops with PCMCIA Slot
- ◆ External pod has joystick port, mic. input, line in & line out jacks, volume control.
- ◆ Install software, inst. included.
- ◆ Win 3.x, W95 compatible
- ◆ New in OEM pkg (no box), 90-day HSC warranty
- ◆ We had these before at \$39.95 and they went fast!

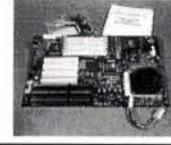


HSC#17036 \$29.95

## Pentium-Pro Power!

High quality Micronics motherboards using the Intel Pentium-Pro chip at incredible savings!

- ◆ **D6-IN "Invader"** AT motherboard has 4 PCI, 3 ISA slots
- ◆ Built-in Primary & Secondary IDE controller, floppy controller, IR port, 2 SIO ports, 1 PIO port
- ◆ Comes with tested 150 MHz CPU installed
- ◆ Supports up to 384K memory (72-pin SIMMs)
- ◆ Comes with instruction book, I/O Cables & bracket
- ◆ New in box, 90-day warranty



\$119.00

- ◆ **W6-LI "Lightning"** dual CPU board has 4 PCI, 2 ISA slots
- ◆ Dual Processor motherboard, can use 1 or 2 CPU chips
- ◆ Comes with one tested 150 MHz CPU installed
- ◆ Voltage Regulator Module for second CPU included
- ◆ Built-in Primary & Secondary IDE controller, floppy controller, 2 USB ports, IR port, 2 SIO ports, 1 PIO port
- ◆ Also has Adaptec "Ultra-SCSI" fast SCSI Bus Mastering controller with 50-pin port and 68-pin ultra-wide port!
- ◆ Also has Creative Labs "Vibra 16CL" sound on board!
- ◆ Supports up to 512K memory (168-pin DIMMs)
- ◆ Full Manual & Disk set (SCSI, sound, etc.), I/O Cables
- ◆ ATX-style motherboard, new in box, 90-day warranty



\$199.00

## Super Skinny Laptop Floppy!

- ◆ Citizen W1D 1.44 MB floppy measures only .43" thick!
- ◆ Interface is 26 conductor 1mm pitch printed ribbon cable
- ◆ Short (1.25") ribbon cable included
- ◆ Black bezel -- New OEM Pack, 90-day warranty
- ◆ Sorry, we do not know which laptops will accept this drive!



\$35.00

## Cases!...Cases!...Cases!

- ◆ Mini-Tower, 3 - 5.25" and 4 - 3.5" bays
- ◆ One slot for 3.5" drive on front panel
- ◆ 15" H x 7" W x 16.5" D
- ◆ Takes standard mini-tower supply
- ◆ See our #17316 (this ad!)

HSC#17481

\$12.50

- ◆ Full-sized tower case, for AT or ATX!
- ◆ Comes w/AT-style power supply
- ◆ ATX cutouts on rear panel, just change to our #XTC312 ATX power supply!
- ◆ 24-1/4" H x 7.5" W x 16-3/4" D
- ◆ Brand new!, black in color

HSC# 17544

\$42.50

- ◆ AT-style Mid-tower
- ◆ Extra PIO and SIO slots on rear panel!
- ◆ 18.5" H x 6-5/8" W x 15.75" D
- ◆ Three 5.25" and two 3.5" front bays
- ◆ Brand new!, black in color

HSC# 17543

\$37.95

- ◆ ATX-style mid-tower cabinet
- ◆ Power supply included
- ◆ Three 5.25" and two 3.5" front bays
- ◆ 16.5" H x 8.25" W x 16.5" D
- ◆ Brand new!, 90-day warranty

HSC# 80459

\$59.50

- ◆ Full-size tower bargain at a great price!
- ◆ Five 5.25" and four 3.5" bays!
- ◆ Extra SIO & PIO connector cutouts!
- ◆ Great for backup server...etc
- ◆ Requires old-style larger power supply (ask for stock check...we might have it!)

HSC# 17504

\$15.00

## Ludicrous Laser Pointer!

- ◆ How can we do this!...we don't even know!...
- ◆ Small, handy laser pen keychain pointer.
- ◆ 5 mW, bright red laser with tight beam
- ◆ Brushed gold finish with spring-loaded clasp
- ◆ Brand new, with batteries and instructions
- ◆ 90-day warranty.



\$12.50!

## Parallel-Port Keyboard!

- ◆ Perfect for notebook computers, laptops, palm-tops, etc.
- ◆ Full-size 101 keyboard by ALPS, model LPT 101
- ◆ Includes manual, installation diskette with Win 3.1 drivers
- ◆ New in OEM box, 90-day warranty
- ◆ New Price!

HSC#17160

\$39.95

## Workhorse Hard Drives!

- ◆ Seagate with SCSI interface full-height drives
- ◆ Good, Reliable drives for many applications
- ◆ Choose from 670 or 330 MB size
- ◆ With 90-day warranty!



HSC#17556

\$35.00

HSC#17557

\$29.00

## Halted specialties co.

# HSC

## Electronic Supply



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<http://www.halted.com>

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(916) 338-2545

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Internet World Wide Web:

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4837 Amber Ln., Sacramento, CA 95841

5681 Redwood Dr., Rohnert Park, CA 94928

## Visit HSC's Website!

- ◆ Pay us a virtual visit on the World Wide Web!
- ◆ Simply point your browser to <http://www.halted.com>
- ◆ Site is constantly being revised, please visit often!
- ◆ Check out the amazing "Gizmo of the Week" feature!

- ◆ That's right, get HSC's catalog on the World-Wide Web!
- ◆ Simply go to [www.halted.com](http://www.halted.com) and follow the big red link.
- ◆ Adobe .PDF files are available for download and viewing.
- ◆ Or drop on by and pick one up...we'd love to see you!

Terms: Some quantities limited; all items subject to prior sale. **Minimum order: \$10.00 plus shipping.** Orders under \$20.00 subject to \$2.00 handling fee, in addition to shipping. All orders shipped FOB Santa Clara, CA (this means you pay freight!) by UPS Surface (no P.O. Boxes) unless otherwise specified, in which case prevailing carrier rate plus \$5.00 handling fee applies. Prepaid orders that don't include shipping charges will be shipped freight C.O.D. There is a \$5.00 UPS charge added to shipping charges for C.O.D. shipments. If you have questions about your order, please call Customer Service at (408) 732-1854 M-F 9AM to 5PM PST.



## OPTOCOM PC-CONTROLLED COMMUNICATIONS RECEIVER

Optoelectronics, Inc. announces the all new Optocom PC-controlled communications receiver. The Optocom is the only PC-controlled communications receiver available today that has the ability to decode and follow both Motorola and LTR trunked systems on any frequency band, including 400 MHz, 500 MHz, 800 MHz, and 900 MHz. Another exclusive Optocom feature is the capability to follow both trunked systems and conventional frequencies simultaneously. In addition to Motorola and LTR decoding, the Optocom also decodes CTCSS, DCS, and DTMF.

The Optocom is a high-speed triple conversion receiver that is the fastest PC-controlled communications receiver available today, scanning at speeds up to 100 channels per second due to another Optocom exclusive feature, pipeline tuning.

The Optocom also provides the exclusive store and scan feature, which allows the user to download up to 28 different frequencies or one talk group ID into the Optocom's internal memory for scanning away from the computer, an ideal way to track one talk group ID in mobile applications.

The Optocom also has a built-in data slicer circuit for decoding of popular FSK programs such as ACARS and WeFax, using third-party software.

Other Optocom features include a CI-5 port for reaction tuning by the popular Scout frequency recorder, squelch and volume controlled by both software and hardware, and dedicated decoder plug-in buss for future third-party applications.

For more information, contact:

**OPTOELECTRONICS, INC.**  
5821 N.E. 14th AVE., DEPT. NV  
FT. LAUDERDALE, FL 33334  
954-771-2050 FAX: 954-771-2052  
E-MAIL: [sales@optoelectronics.com](mailto:sales@optoelectronics.com)  
WEB: [www.optoelectronics.com](http://www.optoelectronics.com)

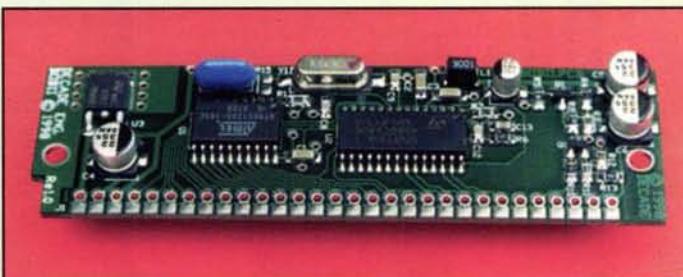
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430 Princeland Court, Corona, CA 91719  
or E-Mail to [newproducts@nutsvolts.com](mailto:newproducts@nutsvolts.com)

## BOB II VIDEO TEXT DISPLAY MODULE

Decade Engineering announces BOB-II, their second-generation video text display module. BOB-II snaps into a common 30-pin SIMM socket and lets your PC or microcontroller display up to 11 lines of 28 characters – 308 total – in standard NTSC or PAL composite video systems. Basic character graphics and Euro language support are provided.

BOB-II generates matte background video on-board, or genlocks to your external video source and superimposes text over the image. Video mode switching is fully automatic. Character transparency and brightness are variable using external pots, if desired. You can draw attention to important messages with character blinking or background display options.

Programmed control of BOB-II is effected by simple commands and text sent as plain ASCII codes through a speedy (9600bps)



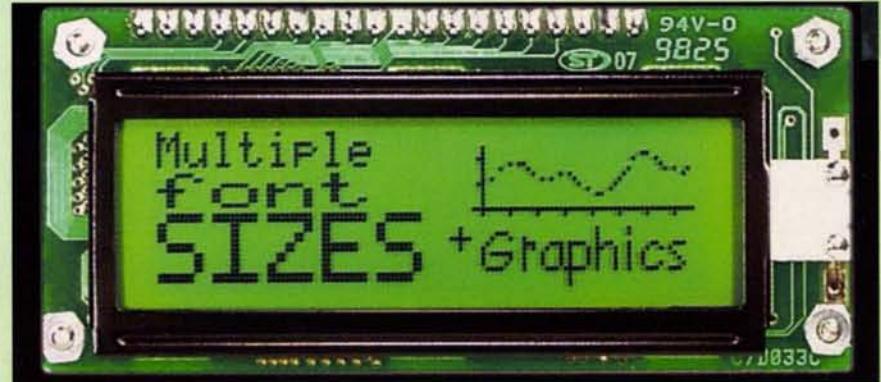
serial data link. Direct control from the PC keyboard is possible with any standard ASCII terminal program, e.g., HyperTerminal.

BOB-II requires 65 mA from an unregulated 12 VDC source, and offers a regulated +5V output to power associated equipment.

BOB-II (NTSC) pricing is \$79.95 for single units. The PAL version is slightly higher.

For more information, contact:

**DECade Engineering**  
5504 VALVIEW DR. S.E., DEPT. NV  
TURNER, OR 97392-9517  
503-743-3194 FAX: 503-743-2095  
E-MAIL: [decade@worldnet.att.net](mailto:decade@worldnet.att.net)  
WEB: [www.decadenet.com](http://www.decadenet.com)



## SGX-120L SERIAL GRAPHICS LCD

The SGX-120L is a graphics LCD with a serial interface. It accepts data over a 2400- or 9600-baud serial connection (e.g., RS-232) and displays text and graphics on a high-contrast 120x32 pixel screen.

Text formatting is straightforward, using standard control characters like carriage returns, tabs, backspace, etc. Additional instructions tap the display's more advanced capabilities, like multiple fonts and font sizes from 4 mm to 8 mm (0.16 to 0.32 in.), automatic right-alignment, backlight control, and reversed (light-on-dark) printing.

Graphics capabilities include plotting points, drawing lines, and displaying full-screen images. The font and up to six screen images are stored in onboard EEPROM. Users can create or edit fonts and up to six screen images in a PC paint program, then download them to the SGX-120L using free software included with the display.

The SGX-120L draws only 10 mA with the LED backlight off and 60 mA with it on. At 80x36 mm (3.15x1.42 in.), it is the same size as a two-line by 16-character text-only LCD.

Pricing for SGX-120L (p.n. SGX-120L) ranges from \$99.00 (quantity 1) to \$69.00 (quantity 100+).

For more information, contact:

**SCOTT EDWARDS ELECTRONICS, INC.**  
1939 S. FRONTAGE RD., STE. F DEPT. NV  
SIERRA VISTA, AZ 85635  
520-459-4802 FAX: 520-459-0623  
WEB: [www.seetron.com](http://www.seetron.com)

## ELECTRONIC MOP

A new electronic motor operated potentiometer for OEM and retrofit applications which replaces existing MOPs with a solid-state device that allows multiple operation stations from one PC board is being introduced by Waddington Electronics, Inc.

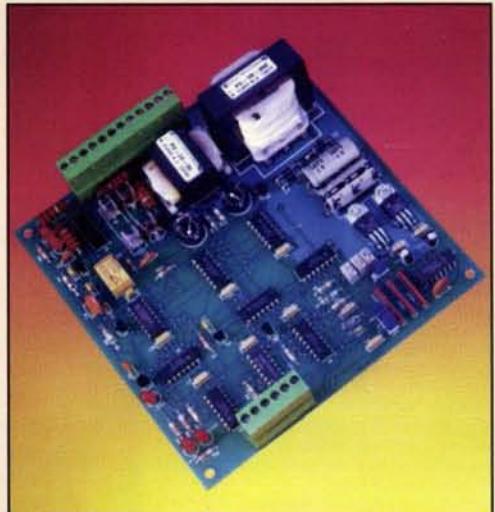
Featuring a separate rate adjustment for increasing and decreasing output and one to increase, decrease, reset, jog, and sum inputs, it has adjustable gain and offset with automatic reset after power on.

Providing differential inverting or non-inverting summing input, selective bipolar (-10 to +10 VDC) or (0 to +10 VDC) output, and selective inverting and non-inverting output, the Waddington Electronic MOP has opto-isolated control input signals.

This versatile board permits the use of internal isolated 24 VDC or external 5 to 240 VAC or DC signals to control inputs.

The Waddington Electronic MOP is priced at \$295.00 (list). For more information, contact:

**WADDINGTON ELECTRONICS, INC.**  
25 WEBB ST., DEPT. NV  
CRANSTON, RI 02920  
401-781-3904 FAX: 401-781-1650  
E-MAIL: [johnwn@ids.net](mailto:johnwn@ids.net)



# Big sound from a stereo radio—without the big price!

Zenith Audio, a leading electronics manufacturer designs a "Small Footprint", "Big Sound" stereo system that's perfect for the home or office and priced below \$100.

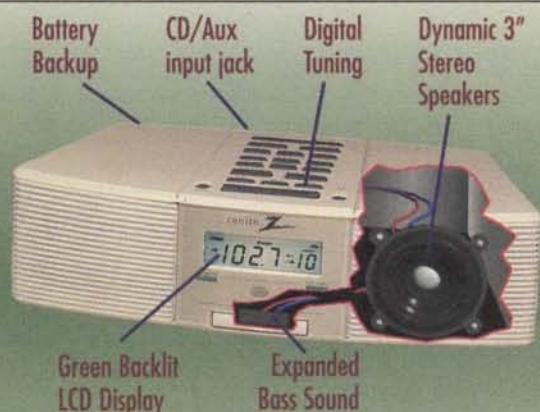
by John Jameson

I leaned back slowly in my chair with my eyes closed, listening to the haunting melody of a Mozart symphony. The acoustics were flawless, and the room was soon filled with full, rich stereo sound. From the crisp highs of the flutes to the tooth-rattling bass of the kettle drums, the music was crystal-clear and powerful. I could distinguish the distinct sounds from each individual musician, and as the orchestra reached the finale I almost fell out of my seat from the awesome force of the music. As the music faded, I leaned forward and hit a button on the stereo clock radio. I had a concert to go to that night—it was time to check the weather.

**Ultimate sound machine.** Zenith Audio has developed a Digital Stereo Clock Radio that boasts the acoustic quality and practical features of stereo radios four times as expensive. You'll be amazed at the sound quality and powerful bass you get from a radio this small and this affordable. This stereo radio features an 11-key handheld remote control and an input jack for CD players or other audio sources.

**The best bass.** Many small stereo radios can sound tiny and weak. This unit has an exclusive EXB button for expanded bass performance. It intensifies the lower tones for CD or FM stations, giving you rich, full and powerful stereo sound. If you want to listen to the stereo in private, there is a headphone jack on the side of the unit.

## Compact Speakers with a Big Sound



The Zenith Audio Clock Radio has an exclusive EXB button for expanded bass performance. It intensifies the lower tones for CD or FM stations, giving you rich, full and powerful stereo sound.



## Micro-Electronic Sound Breakthrough

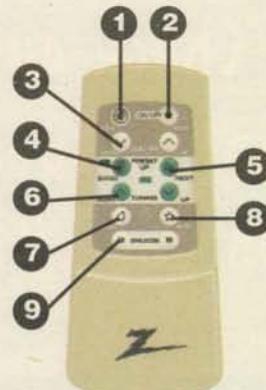
**State of the art stereo sound quality in a stylish cabinet**

■ AM/FM/TV Bands	■ Ascending Tone
■ Stereo Speakers with Crystal Sound System	■ Alarm
■ Digital Weather Band	■ Wake/Sleep to Radio, Weather or TV Band
■ 37 Preset Station Memories	■ "Fail-safe" Alarm System

## Factory direct risk-free offer.

You can spend hundreds of dollars more on a stereo radio, but why do it? We get the Stereo Clock Radio direct from Zenith Audio and pass the savings on to you. This product comes with a one-year manufacturer's limited warranty and Comtrad's exclusive risk-free home trial. If you are not satisfied for any reason, simply return it within 90 days for a full "No Questions Asked" refund.

- 1 Mute
- 2 Power
- 3 Volume
- 4 Band
- 5 Preset
- 6 Tuning
- 7 Alarm
- 8 Sleep
- 9 Snooze



11-key full function remote works up to 15 feet away.

The Zenith Crystal Clear Stereo comes in white or black.



**Zenith Crystal Clear Stereo \$99.95 \$12 S&H**  
Please specify white or black.

Please mention promotional code 4244-14637

For fastest service, call toll-free 24 hours a day

**800-992-2966**



To order by mail, send check or money order for the total amount including S&H. To charge it to your credit card, enclose your account number and expiration date.

Virginia residents only—please include 4.5% sales tax.

**comtrad industries**  
2820 Waterford Lake Dr., Suite 102  
Midlothian, Virginia 23113

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with Nuts & Volts!*

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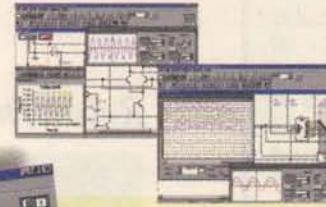
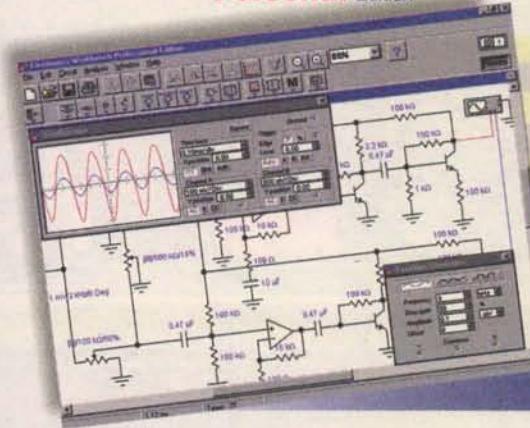
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# The Computer Controlled World: RS-232 Network Control Methods and Applications

by Ryan Sheldon, National Control Devices (404) 244-2432 <http://members.aol.com/ncdcat>

## Serial

## Killers

FIGURE 1

Last month, I talked about controlling relays, graphic LCD displays, and A/Ds from a single serial port. While these are popular topics, I have received a large number of questions pertaining to general RS-232 communications. I want to clarify a few things in this month's article in hopes that readers get a better idea of RS-232 serial capabilities and limitations. In effect, I want my readers to know what inhibits (or kills) serial communications.

I will use the relay driver as an example to help clarify the questions I have received. Since this device is easy to program, readers will be able to concentrate on software and electrical issues rather than schematics and hardware. The relay drivers shown in this article will literally show you communication errors. By that, I mean corrupt data will usually appear as an unexpected relay activation/deactivation during a serial transmission.

### How Far?

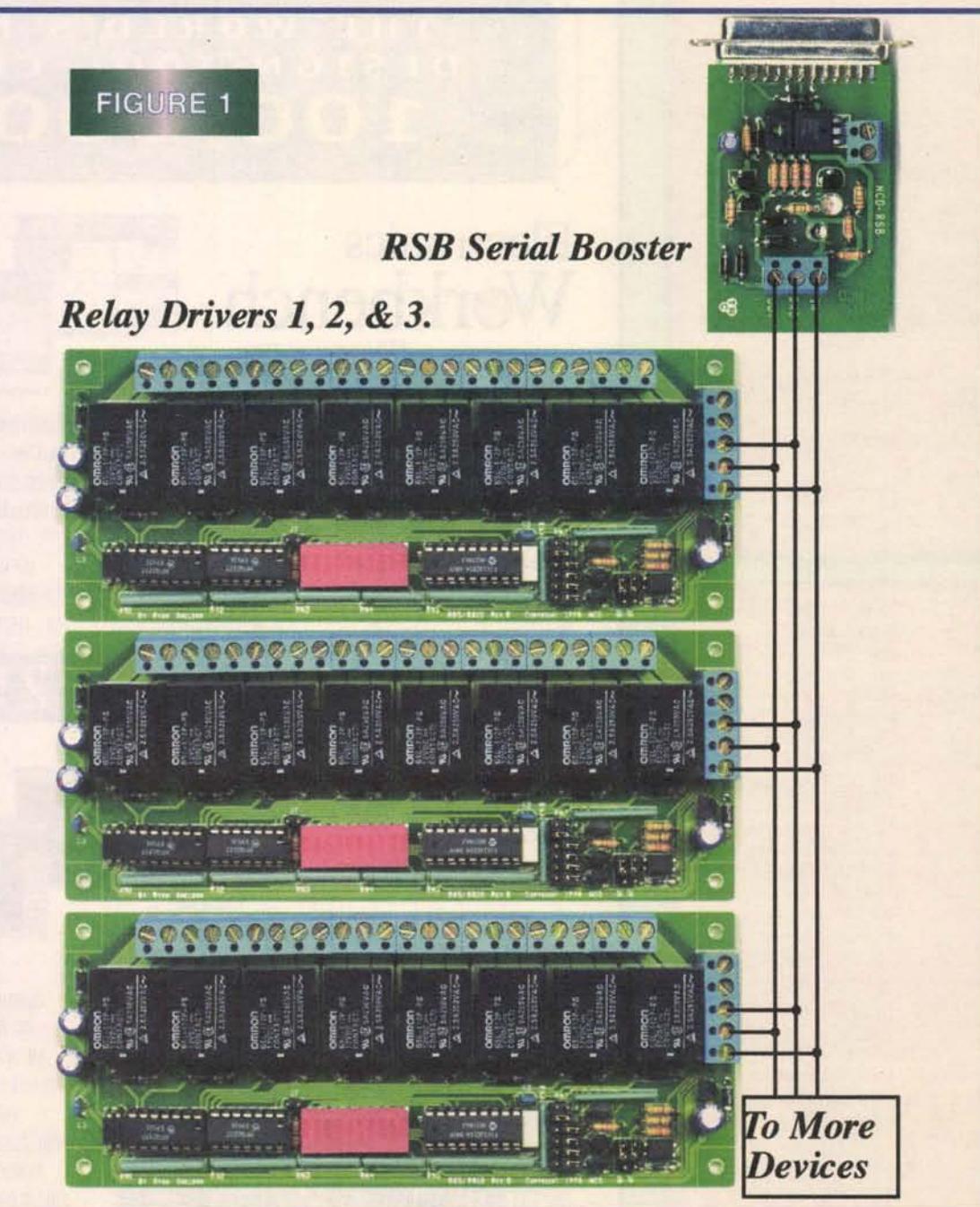
Perhaps the biggest question that I get with regard to RS-232 communications is distance. How far can you go? Well, there is no universal answer to this question. Some RS-232 peripheral devices may not operate beyond 12 feet, others may operate perfectly at a thousand feet. Distance is limited by four things:

- 1) Power: How powerful the port drivers are in your computer and attached device.
- 2) Speed: How fast you need to send and receive data.
- 3) Wire: Type of wire being used for communication.
- 4) Load: How much power is taken from the serial port from a driven device.

### Power

The "RS" in RS-232 stands for "Recommended Standard" and, as such, is employed loosely by many computer manufacturers. While most desktop systems provide a powerful RS-232 signal ( $\pm 10$  to 12 volts at 3mA), many laptops make use of low-power circuitry that usually compromises communications strength (usually  $\pm 8$  to 12 volts at 1mA).

Some microcontrollers (including the



Basic Stamp and some of our own devices) conform to the RS-232 timing standard only. So instead of generating a  $\pm 12$  volt signal, a standard logic-level (0/+5 volt) signal is used. A logic level RS-232 signal is not very powerful and should not be used for communicating data back to the computer beyond 10 feet. Without exception, all tested IBM-compatible PCs are capable of receiving logic level data without any problems. However, Macintosh systems require a true RS-232 signal for all

inbound communications.

### Speed

Another very important factor in RS-232 communications is speed (baud rate). The faster you send data out your serial port, the shorter the communication distance. At high baud rates, data pulses are very short and become very susceptible to noise. At low baud rates, an RS-232 signal can travel great

distances. For example, I have tested 9600 baud over a distance of 1,000 feet with excellent results. Similar tests showed communications limitations of 60 feet at 115,200 baud.

## Wire

Wire plays a very important role in RS-232 communications. I recommend the use of stranded insulated copper wire for best results. An average to heavy gauge (such as 12 or 10) is preferred. What you want to avoid is resistive and capacitive wire such as COAX and most stranded telephone cables.

Just keep in mind that anything that is capacitive corrupts data pulses by turning square waves into jagged waves. Resistive wire tends to weaken the signal strength. COAX is both resistive and capacitive, making it impossible to use for data communications unless used in combination with RF transceiver circuits such as those found in ethernet (thin-net) networking cards and hubs.

I have used stranded 15 gauge copper with good results, but would recommend a heavier wire if available. Solid copper telephone wire also works well and is often used by many readers in industrial installations.

## Load

Say you have 12 light bulbs you want to power from a single battery. You attach the first bulb and the light is very bright. You attach the second bulb, and the first light gets a little dimmer, but both light brightly. As you keep attaching bulbs, the previously attached lights keep getting a little dimmer. The light bulbs are your load, and you may drive a few light bulbs at an acceptable brightness.

RS-232 communications suffers from the same problem. Except the RS-232 port is your battery and the device you want to drive is your light bulb. As you keep attaching devices to the serial port, the output power becomes weaker and weaker, until finally, the signal is corrupt and data can no longer control any device with reliability.

This scenario is more real than you might think. Many devices such as the relay controller discussed later in this article are optoisolated. In other words, they each have an invisible light bulb (LED) attached to the serial port used to protect the computer and

the device from each other in the event of an electrical malfunction. LEDs will load down an RS-232 port, as well as a logic-level data signal from a BASIC Stamp. Though not recommended, a BASIC Stamp can usually drive five optoisolators from a single output pin without problems. Beyond that, the signal MUST be boosted.

## RS-232 Network Solutions

Since RS-232 standards are employed randomly from manufacturer to manufacturer, and since our application requires speed, distance, and heavy loading, a supplemental circuit must be used to provide the necessary communications power.

The RSB serial booster shown in Figure 1 delivers high-current -3/+12 volt data at speeds up to 38.4K. The RSB can deliver data to 20 optoisolated devices and has been tested over a distance of 1,000 feet. The RSB is equipped with a DB-25 female connector for direct connection to your computer. You will need to supply a minimum of 15 volts to properly power the board.

The RSB has a simple three-terminal connector labeled IN, GND, and OUT. The ground is shared with the RS-232 ground of all networked devices. The OUT delivers high-current data to all attached devices. The IN connector accepts open collector data (which is equivalent to high-speed switch closures to ground) and converts it back into a compatible RS-232 data signal. This allows up to 16 devices to share a three-wire interface. Simply add devices as needed by chaining them together from this three-wire interface.

## Protocol

Now that data has been fed to all three relay drivers, you can now speak to each driver board individually by using a very simple addressing system. To understand this system, you have to know that your computer is capable of sending ASCII characters 0 to 255 out the serial port.

Each relay driver board listens to a user-defined set of 16 ASCII characters. For instance, relay dri-

ASCII Character	Action	Special Notes
0	Turn Off Relay 1 on Relay Board 1	ASCII Characters 0 to 15 Control Relay
1	Turn Off Relay 2 on Relay Board 1	Driver Board #1. Jumpers J1-J4 Should
2	Turn Off Relay 3 on Relay Board 1	All Be Removed.
3	Turn Off Relay 4 on Relay Board 1	
4	Turn Off Relay 5 on Relay Board 1	
5	Turn Off Relay 6 on Relay Board 1	
6	Turn Off Relay 7 on Relay Board 1	Send Command 3 Times to Turn Off Relay 8
7	Turn Off Relay 8 on Relay Board 1	AND Report Status of all 8 Relays.
8	Turn On Relay 1 on Relay Board 1	
9	Turn On Relay 2 on Relay Board 1	
10	Turn On Relay 3 on Relay Board 1	
11	Turn On Relay 4 on Relay Board 1	
12	Turn On Relay 5 on Relay Board 1	
13	Turn On Relay 6 on Relay Board 1	
14	Turn On Relay 7 on Relay Board 1	Send Command 3 Times to Turn On Relay 8
15	Turn On Relay 8 on Relay Board 1	AND Report Status of all 8 Relays.

FIGURE 2

ASCII Character	Action	Special Notes
16	Turn Off Relay 1 on Relay Board 2	ASCII Characters 16 to 31 Control Relay
17	Turn Off Relay 2 on Relay Board 2	Driver Board #2. Jumpers J1 Should Be
18	Turn Off Relay 3 on Relay Board 2	Installed, J2-J4 Should Be Removed.
19	Turn Off Relay 4 on Relay Board 2	
20	Turn Off Relay 5 on Relay Board 2	
21	Turn Off Relay 6 on Relay Board 2	
22	Turn Off Relay 7 on Relay Board 2	Send Command 3 Times to Turn Off Relay 8
23	Turn Off Relay 8 on Relay Board 2	AND Report Status of all 8 Relays.
24	Turn On Relay 1 on Relay Board 2	
25	Turn On Relay 2 on Relay Board 2	
26	Turn On Relay 3 on Relay Board 2	
27	Turn On Relay 4 on Relay Board 2	
28	Turn On Relay 5 on Relay Board 2	
29	Turn On Relay 6 on Relay Board 2	
30	Turn On Relay 7 on Relay Board 2	Send Command 3 Times to Turn On Relay 8
31	Turn On Relay 8 on Relay Board 2	AND Report Status of all 8 Relays.

FIGURE 3

ASCII Character	Action	Special Notes
32	Turn Off Relay 1 on Relay Board 3	ASCII Characters 32 to 47 Control Relay
33	Turn Off Relay 2 on Relay Board 3	Driver Board #3. Jumpers J2 Should Be
34	Turn Off Relay 3 on Relay Board 3	Installed, J1-J3, and J4 Should Be Removed.
35	Turn Off Relay 4 on Relay Board 3	
36	Turn Off Relay 5 on Relay Board 3	
37	Turn Off Relay 6 on Relay Board 3	
38	Turn Off Relay 7 on Relay Board 3	Send Command 3 Times to Turn Off Relay 8
39	Turn Off Relay 8 on Relay Board 3	AND Report Status of all 8 Relays.
40	Turn On Relay 1 on Relay Board 3	
41	Turn On Relay 2 on Relay Board 3	
42	Turn On Relay 3 on Relay Board 3	
43	Turn On Relay 4 on Relay Board 3	
44	Turn On Relay 5 on Relay Board 3	
45	Turn On Relay 6 on Relay Board 3	
46	Turn On Relay 7 on Relay Board 3	Send Command 3 Times to Turn On Relay 8
47	Turn On Relay 8 on Relay Board 3	AND Report Status of all 8 Relays.

FIGURE 4

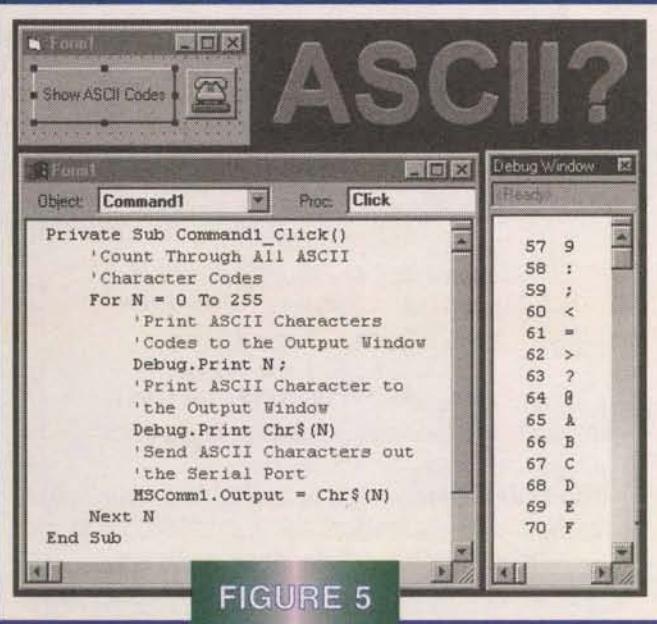


FIGURE 5

ver board #1 listens to ASCII characters 0 to 15. Relay driver board #2 listens to ASCII characters 16 to 31. Relay driver board #3 listens to ASCII characters 32 to 47. A set of four jumpers (J1-J4) defines which set of ASCII characters the relay driver board will respond to. See Figures 2, 3, and 4 for complete details on controlling each device.

## ASCII Characters

One quick note worth mentioning about ASCII characters: ASCII characters are sent using their character codes. For example, the ASCII character "A" is sent using the ASCII character code 65. It is much easier to send

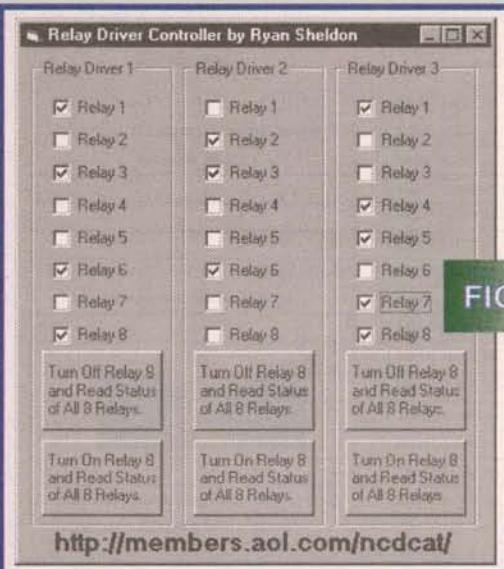


FIGURE 6

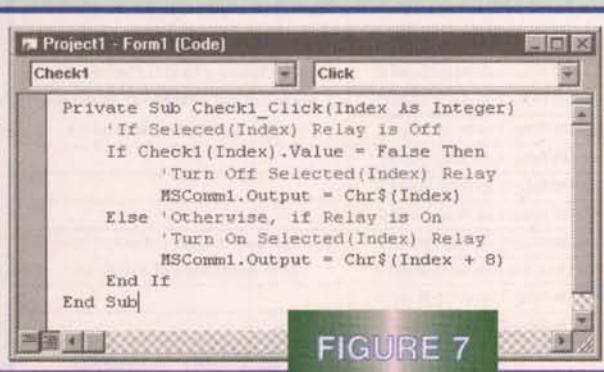


FIGURE 7

the ASCII character codes (number 0 to 255) than it is to send the actual letters and numbers. Figure 5 demonstrates a quick program that lets you see the difference between ASCII characters and character codes. The demo program also shows how to send these codes out the serial port by making use of the MSComm Control under Visual Basic 5 Professional.

### Controlling Relays

The RS-232 relay drivers shown in Figure 1 were designed for ease of use and simple troubleshooting. When properly powered, the heartbeat LED will begin flashing. The heartbeat LED indicates that power is properly applied and that the microprocessor is operating correctly.

As data is received, the "Data Received" LED will flash. This LED flashes any time data is detected on the serial port, regardless of which device the data is speaking to. This LED will flash on all three relay drivers during ANY data transmission.

The relay drivers shown in this article can be operated at 1200, 9600, and 19.2K baud (two stop bits at 19.2K baud) making them easy to interface to just about any computer or microcontroller. As control characters are received, you will hear the relays click on and off. A status LED will also indicate the on/off state of each relay on each board.

Figure 6 illustrates a simple program that I have written to control each of the three relay drivers from a Visual Basic application. Figure 7 shows just how easy it is to control these relay drivers. When a check mark box is clicked, this short program evaluates which box was clicked and the current status. This routine then sends an appropriate ASCII character out the serial port using the MSComm control.

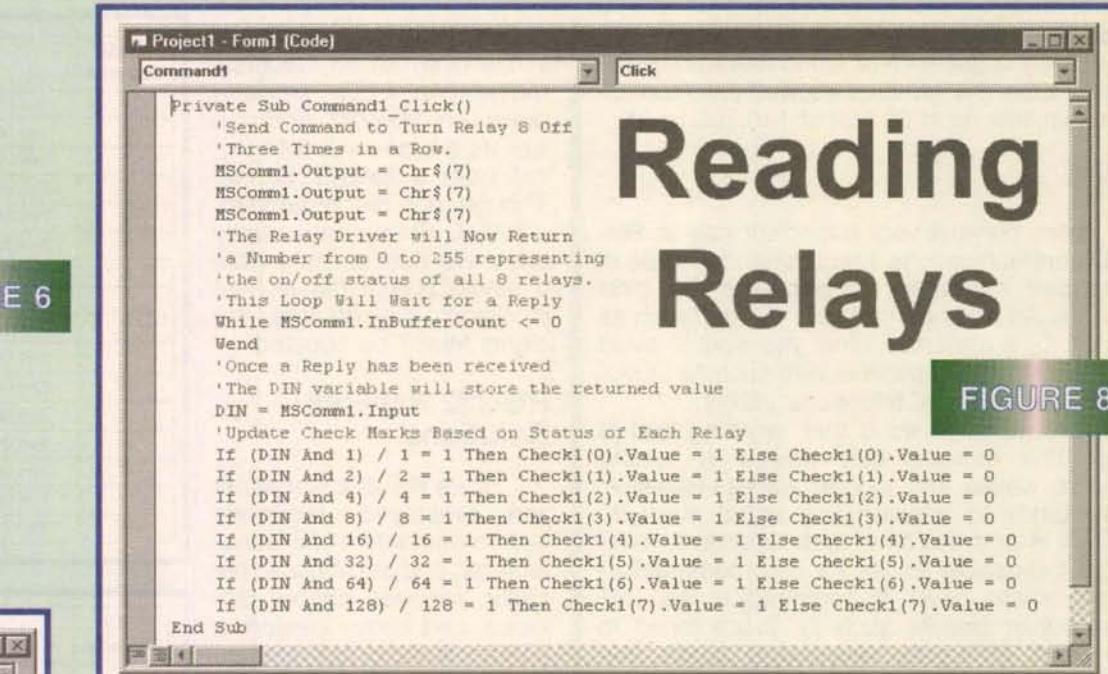


FIGURE 8

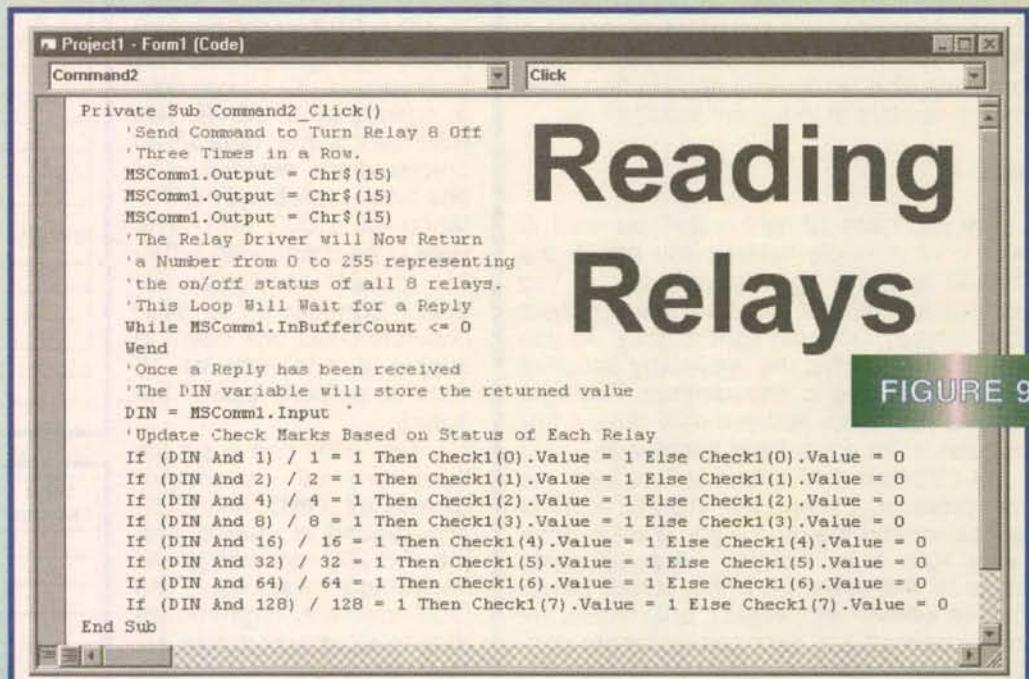


FIGURE 9

Up to 16 relay controllers may be driven from a single RS-232 serial port. Each relay controller can report the status of the eight relays by sending the command to turn relay 8 on or off three times. This function is convenient for industrial applications that may require rock-solid reliable two-way communications.

Figures 8 and 9 show example code for reading the status of all eight relays. The read function requires that you send the command to speak to relay 8 three times in a row. Once issued, the relay controller will return a byte from 0 to 255. A 0 indicates all relays are off. A 255 indicates all relays are on. Any number in between represents the binary status of the relays. The final portion of this subroutine updates the check boxes providing a visual on-screen display of the current relay status.

Relay drivers have found their way into many control applications. They have been used to control lights, motors, speakers, sprinkler systems, alarm systems, and even explosives on many movie sets. Since it is easy to determine the on/off state of the relays

from a remote location, many industrial users have been able to use them in a variety of manufacturing installations. Surprisingly, these relay controllers are most commonly used in factories that are in the process of automating old manufacturing equipment by adding centralized remote operation.

Thanks again for reading this month's "Computer Controlled World," and don't hesitate to call me at (404) 244-2432 or write me at [ncdryan@aol.com](mailto:ncdryan@aol.com) if you have any questions. NV

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## The Computer Controlled World



# A New Use for an Old Switch

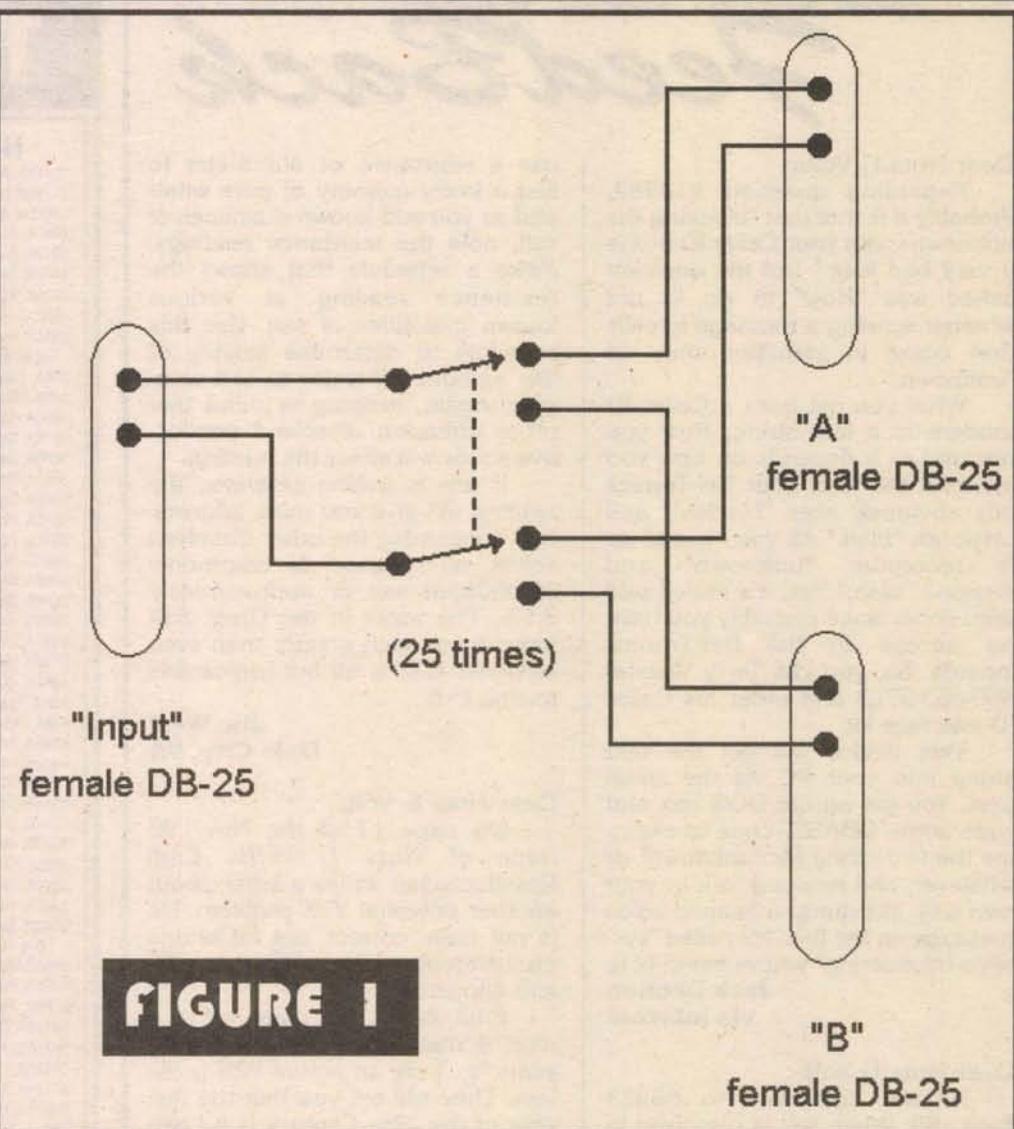
I have used a PC fax/modem for several years and like the convenience of sending faxes directly from my word processor without having to print them. However, I have never been happy using the modem to receive faxes, both because it ties up the computer while the fax is coming in, and because it is necessary to leave the computer and fax software running whenever a fax might arrive. Given these reasons and the frequent need to send non-computer-generated documents, I finally bought a stand-alone fax machine.

Sharing a residential phone line with a fax machine can also be a minor pain, even with a "smart" switch (about \$80.00, more than I wanted to spend) that is supposed to recognize the type of an incoming call and route it appropriately. Add a second phone line (due to an Internet account and the desire to stay married) and the stage is set: manage two phone lines, a heavily used modem, an occasional outbound fax via modem, in and out faxes on the stand-alone machine, and do it without using an automatic switch.

All this, plus honor the small print in the fax machine's manual: don't share the fax machine's phone line with a modem because they might try to sing duets during data transfers. Also, since a manual switch was my preference, it would be good to have some indicator lights to remind me to set everything back to "normal" any time

I changed it.

After pricing multiple pole, multiple throw switches, and not wanting to wait for mail order delivery, I decided to try to come up with an alternative solution. Looking through my junk box for possible switching components, I came across an old printer A/B box which was designed to allow one computer to use two printers or two computers to use one printer.



**FIGURE 1**

Phone Line 1

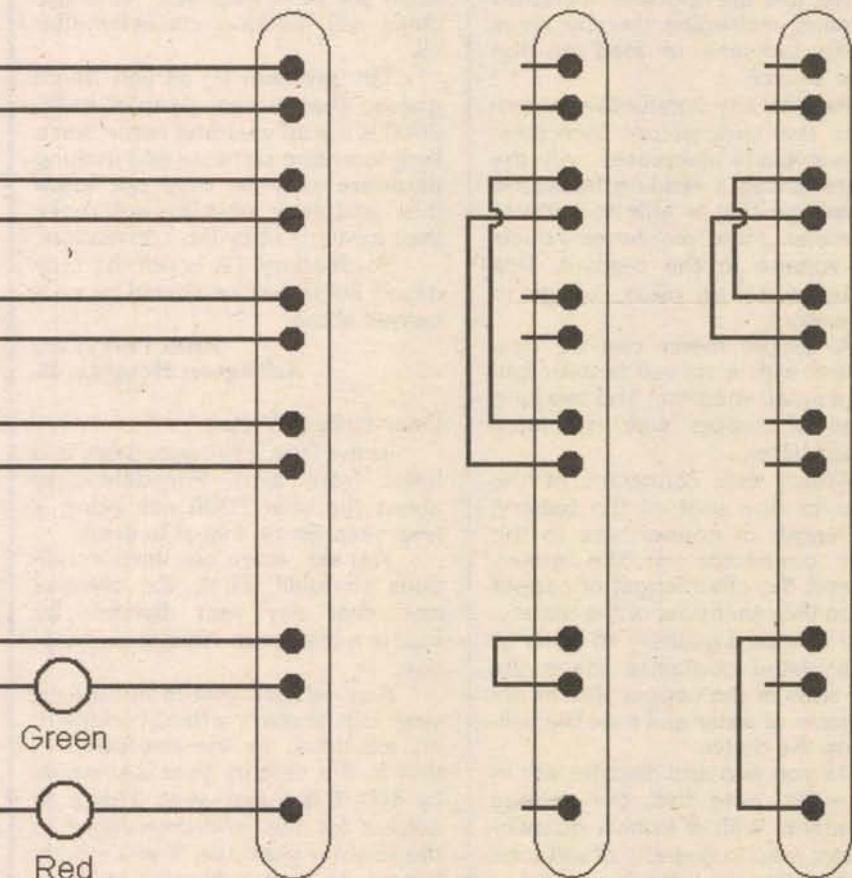
Phone Line 2

Modem

Fax Machine

Indicator Lights

DC Supply



**FIGURE 2**

"Input"

"A"

"B"

Phone Line 1

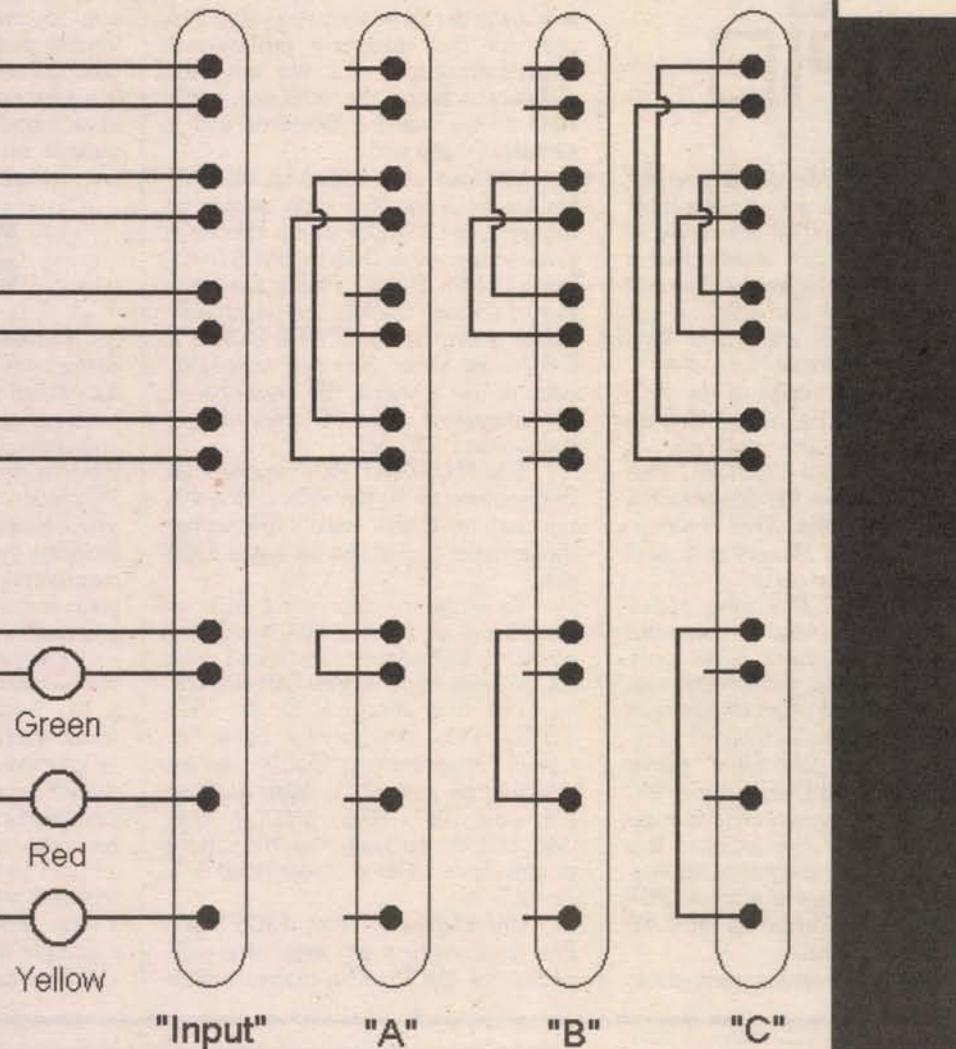
Phone Line 2

Modem

Fax Machine

Indicator Lights

DC Supply



**FIGURE**  
**3**

It consists of a 25-pole, double-throw switch in a case and had three female DB-25 connectors on the rear (input/A/B) and a two position switch (A/B) on the front (see Figure 1). As I was starting to cannibalize the switch for this project, it dawned on me that there was a much better way to utilize the A/B box.

Since there are 25 switched lines (some A/B boxes switch fewer, sometimes 24) and an inexpensive DB-25 connector on each end, I decided to use the set of 25 lines as a sort of bus. I connected the pairs of wires for each of the two outbound phone lines, the modem ("wall" jack), the fax machine ("wall" jack), and the indicator lights wiring to arbitrary pins of a male DB-25 and plugged it onto the "input" connector.

I then wired another DB-25 with jumpers which con-

nected these "bus" wires together in the desired combination and plugged it onto the "A" connector. When the switch is in the "A" position, this connector routes the inputs appropriately.

I wired a third male DB-25 with a different jumper arrangement and plugged it onto the "B" connector, and the project was done. Critical issues are using a DC source for the lamps and observing polarity of the phone lines throughout. See Figure 2.

In this arrangement, line one remains unswitched and goes to the various extension telephones and the answering machine elsewhere in the house. Line two switches between the fax machine and the modem, with a green light indicating the fax machine is able to receive calls (the normal state of things), and a red light meaning that faxes cannot be received. When I get off

of the Internet in the wee hours of the morning, the red light is supposed to remind me to flip the switch.

Later, I came across a surplus A/B/C printer switch box which I now use in place of the original A/B switch. They work the same, but the A/B/C switch uses a 25-pole, three-throw switch and has a third output connector and switch position. My previously wired connectors all work on it without modification, plus I now have an additional switch position which provides a third wiring arrangement. My current configuration is shown in Figure 3.

This wiring arrangement switches both phone lines. In the "A" position, extension phones are on line one, the fax machine is on line two, and the green light is on. In the "B" position, extension phones are on line one, the modem is on line two, and the red light is on. In the "C"

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position, both extension phones and the fax machine are on line one, the modem is on line two, and the yellow light is on.

This third position allows me to send or receive a fax manually during a voice conversation on line one, as well as to exchange faxes between the modem and fax machine for testing, or to inspect print and scan quality. The reason for not having the fax machine on line one under normal conditions is to keep it from answering incoming voice calls.

I have found this solution works well, and the total new parts cost was four male DB-25 connectors at 39 cents each (optional hoods are considerably more expensive). I can also wire additional connectors at any time to reconfigure the switch. Furthermore, although I hope my shared printer days are over, the original A/B and A/B/C boxes are unmodified and as good as ever. NV

# Programming a Microchip PIC

I'm probably safe in assuming that you've heard about the Microchip PIC microcontrollers. You may have surfed a few websites or read an article about them. You might have even used a BASIC Stamp and learned it is built around a Microchip PIC microcontroller. No matter what road you took to understand what a Microchip PIC is, at some point you'll want to get your hands on a PIC and actually program it.

To program a PIC requires a PIC part, a program, and a PIC programmer. Because Microchip PICs are so popular, you have many programmer options to choose from. To cover every option available would be impossible. Instead, I decided to focus on four programmer packages to get you started. From these, you should be able to guide yourself down the path that is right for you. Let's start at the top with Microchip.

## Microchip PICSTART Plus

As the PICs have evolved, so have the programmers from Microchip. The

PICSTART Plus is Microchip's current "low-cost" offering for development work. It could be called affordable at \$199.00, but you can usually find a deal through Microchip that will let you buy it for \$149.00. Just keep an eye on their website or contact a local Microchip representative.

The main advantage to the PICSTART Plus is the support from Microchip. When any new part is released, free updated PICSTART Plus software is available for download at the Microchip website. This is important to me because Microchip is constantly releasing new parts.

The PICSTART Plus programmer is very easy to use and is controlled through your computer's serial port. The PICSTART Plus also comes with everything you need to get started right away (except a Windows-based computer). The serial port cable, power supply, and a 16F84 flash memory PIC that can be reprogrammed multiple times are included. Also included is a CD that has sample programs, application notes, data sheets in acrobat .PDF format, and the Microchip MPLAB simulator ready to install.

MPLAB is a great environment to

develop your PIC assembly code in. It is actually the same software Microchip uses for their high-cost professional emulation system. It's the emulator software without the emulator hardware so it's called a simulator and it simulates really well.

You can also download MPLAB for free from the Microchip website or request the CD-ROM if you choose a programmer other than the PICSTART Plus. The PICSTART Plus is fully supported through the MPLAB which simplifies using the PICSTART Plus to a few mouse clicks. You can write your code or use a sample file, assemble it, and program it into a PIC part without ever leaving MPLAB.

The PICSTART Plus supports all the eight-pin to 40-pin PICs with a 40-pin zero insertion force (ZIF) socket that accepts dual in-line packages (DIP) only.

To program other parts such as surface-mount devices (SMD) requires a SMD to DIP adapter. You'll find most PIC programmers include DIP sockets.

The one drawback to the PICSTART Plus involves the Serial In-Circuit Programming (SICP) feature available on most PICs. With just five PIC pins RB7, RB6, /MCLR, Vdd (5V), and Vss (ground), the PIC can be programmed while still connected in a circuit.

Unfortunately, the PICSTART Plus does not have any expansion connector for (SICP). The drivers within

the PICSTART Plus won't even allow you to make a custom ZIF socket jumper that will work. Despite this, if you can afford it, the PICSTART Plus is a great option and you'll know you're always going to be supported by the makers of the PIC. Check it out at [www.microchip.com](http://www.microchip.com).

## Parallax PIC Programmer

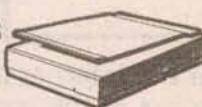
Parallax, makers of the BASIC Stamp, also offer a PIC programmer. It's offered in two versions: a complete package and the hobbyist pack. The complete package costs \$199.00 and includes programmer, printed manual, PC cable, software, and power adapter. The hobbyist pack costs \$109.00 and includes programmer, software, and manual on disk so you have to build your own cable, find a power source, and read or print the manual from disk.

The programmer is pretty easy to use so having the manual on disk is not a big hassle. Parallax also includes some sample files so you can use the programmer, but you have to supply the PIC part or buy one from Parallax since that's not included. The programmer cable connects from the PC parallel port to the programmer through a modular phone jack plug. This makes it more difficult to find your own cable if you get the hobbyist package.

You can use a 25-pin header to

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TEK SC502 15 MHz Dual Trace Oscilloscope, TM500 series	\$375.00

### ABOVE 100 MHz

TEK 2465 300 MHz 4-channel Oscilloscope	\$2,500.00
TEK 7104 1 GHz Oscilloscope, with 7A29, 7A29-04, 7B15	\$4,500.00
TEK 7844 400 MHz Dual Beam Oscilloscope frame	\$600.00
TEK 7844 .400 MHz Dual Beam Oscilloscope with 7A24, 7A26, 7B80, 7B85	\$1,000.00
TEK 7904A .500 MHz System, with 7A24, 7A26, 7B80, 7B85	\$1,250.00

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TEK 7A19 600 MHz Single Trace Amplifier	\$150.00
TEK 7A24 400 MHz Dual Trace Amplifier	\$300.00
TEK 7A26 200 MHz Dual Trace Amplifier	\$175.00
TEK 7A42 4-Channel Logic Triggered Vertical Amplifier	\$500.00
TEK 7B15 1 GHz Delaying Time Base	\$450.00
TEK 7B80 400 MHz Delayed Time Base	\$175.00
TEK 7B85 400 MHz Delta Delaying Time Base	\$175.00
TEK 7B92A 500 MHz Dual Time Base	\$275.00

### STORAGE

TEK 7633 100 MHz Storage Oscilloscope frame	\$600.00
TEK 7633 100 MHz Storage Oscilloscope with (2) 7A26, (1) 7B92A	\$900.00

### PROBES

HP 1122A Probe Power Supply	\$150.00
TEK 1101 Accessory Power Supply, for FET probes	\$250.00
TEK P6046 100 MHz Differential Probe	\$750.00
TEK P6201 900 MHz 1X/10X/100X FET Probe	\$450.00
TEK P6202A 500 MHz 10X FET Probe	\$300.00
TEK P6203 1 GHz 10X Active Probe, for 11000 series	\$375.00
TEK P6701-opt.02 O/E Converter, 450-1050 nm/0-1 mW: DC-700 MHz, ST conn.	\$375.00

### CALIBRATION

TEK SG503 Level Generator, 250 kHz-250 MHz, TM500 series	\$600.00
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## WAVEFORM GENERATORS

HP 3310A 5 MHz Function Generator	\$250.00
HP 3310B 5 MHz Function Generator, monocycle & var.phase trigger	\$325.00
HP 3312A 13 MHz Function Generator	\$650.00
HP 3325A 21 MHz Synthesized Function Generator, HPIB	\$1,650.00
HP 3325A-002 21 MHz Function Generator, high voltage output option	\$1,750.00

HP 8165A-002,003 Prog. Signal Source, 1 mHz-50 MHz, log sweep, rear out	\$2,000.00
HP 8904A-002,004 Multifunction Synthesizer, DC-600 kHz, HPIB	\$2,500.00
TEK AWG5102 Arb.Waveform Gen., 20 MS/s,12 bits,50ppm synthesis <1MHz	\$900.00
TEK AWG5105-opt.02 Arbitrary Waveform Generator, dual channel option	\$1,250.00
TEK DD501 Digital Delay & Burst Gen., for function & pulse gen's	\$275.00

TEK FG501 1 MHz Function Generator, TM500 series	\$225.00
TEK FG502 11 MHz Function Generator	\$300.00
TEK FG503 3 MHz Function Generator, TM500 series	\$250.00
TEK RG501 Ramp Generator, TM500 series	\$225.00
WAVETEK 185 5 MHz Lin/Log Sweep/Function Generator	\$300.00

WAVETEK 288 20 MHz Synthesized Function Generator, GPIB	\$750.00
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BERKELEY NUCLEONICS 7085B Digital Delay Generator, 0-100 mS, 1 nS res.,5 Hz-5 MHz	\$750.00
HP 8007B 100 MHz Pulse Generator	\$650.00
HP 8012B 50 MHz Pulse Generator, variable transition time	\$600.00
HP 8015A-002 50 MHz Dual Output Pulse Generator, gated burst option	\$750.00
HP 8080A/81A/83A/84A 300 MHz Word Generator	\$800.00

HP 8080A/91A/92A/93A 1 GHz Single Channel Pulse Generator	\$950.00
HP 8111A 20 MHz Pulse / Function Generator	\$1,500.00
HP 8115A 50 MHz Dual Channel Pulse Generator, HPIB	\$3,500.00
TEK PG502 250 MHz Pulse Generator, T<1nS, TM500 series	\$600.00

TEK PG505 100 kHz Pulse Generator, 80 V peak, TM500 series	\$275.00
TEK PG508 50 MHz Pulse Generator, TM500 series	\$500.00
WAVETEK 802 50 MHz Pulse Generator	\$300.00

## VOLTAGE & CURRENT

### VOLTMETERS

FLUKE 845AR High Impedance Voltmeter / Null Detector	\$500.00
HP 3456A 6-1/2 Digit Voltmeter	\$750.00
HP 3478A 5-1/2 digit Multimeter, HPIB	\$700.00
KEITHLEY 155 Null Detector/ Microvoltmeter, 1 uV-1000 V I.s.	\$200.00
KEITHLEY 181 6-1/2 digit Nullvoltmeter, 10 nV sensitivity, GPIB	\$900.00
SOLARTRON 7081 8-1/2 digit Voltmeter	\$3,900.00
TEK DM501A 4-1/2 digit Multimeter, TM500 series plug-in	\$225.00

## CALIBRATION

FLUKE 510A AC Reference Standard, 10 VRMS, 0-10 mA	\$450.00
FLUKE 515A Portable Calibrator, DC/AC/Ohms, line & battery power	\$900.00
FLUKE 5220A Transconductance Amplifier, DC-5 kHz, 0-20 A	\$3,000.00
FLUKE 720A 7-decade Kelvin-Varley Voltage Divider	\$1,250.00
FLUKE 731B DC Reference Standard	\$400.00
FLUKE 732A DC Voltage Standard	\$2,000.00
HOLT 11 AC Thermal Converter Set, 0.5-1200 V, 20 Hz-30 MHz	\$2,000.00
VALHALLA 2703 AC Volt.Std., 0-120V/10 Hz-100 kHz;120-1200V/10 Hz-1 kHz	\$2,250.00

## VOLTAGE SOURCES

HP 6115A Precision Dual Range Power Supply, 50V 0.8A / 100V 0.4A	\$850.00
KEITHLEY 228 Programmable Voltage/Current Source	\$2,500.00

## CURRENT METERS & SOURCES

HP 4140B Picammeter / DC Voltage Source, without test fixture	\$2,000.00
HP 6177C DC Current Source, to 50V, 500mA	\$500.00
HP 6181C DC Current Source, to 100 V, 250 mA	\$500.00
HP 6186C DC Current Source, to 300V, 100mA	\$750.00
KEITHLEY 220 Programmable Current Source, 0.5 pA-10 mA, 1-105 V lim	\$2,000.00

## IMPEDANCE & COMPONENT TEST

### L.C.R.

BOONTON 62AD 1 MHz Inductance Meter, 2-2000 uH	\$550.00
BOONTON 72BD 1 MHz Capacitance Meter, 3-1/2 digit display	\$650.00

HP 4262A-101 3-1/2 digit LCR Meter, 120 Hz/ 1 kHz/ 10 kHz test, HPIB	\$2,250.00
HP 4275A-001 5-1/2 digit LCR Meter, 10 kHz-10 MHz, 0-35 V int. bias	\$5,000.00

### STANDARDS

E.S.I. DB62-11K 6-Decade Resistor, 0-11,111.10 Ohms, 0.01 Ohm res.	\$300.00
E.S.I. SR1010 Resistance Transfer Standards, 1 Ohm-100 K/step	\$550.00
E.S.I. SR1050-1M Resistance Transfer Standard, 1 Megohm/step	\$2,000.00

GR 1404-A 1000 pF Reference Standard Capacitor	\$700.00
GR 1406 Standard Air Capacitors, GR900 connector, 0.1% acc.	\$375.00
GR 1412-BC Decade Capacitor, 50 pF - 1.11115 uF	\$350.00
GR 1432-U 4-Decade Resistor, 0-11.110 Ohms, 0.01 Ohm resolution	\$125.00
GR 1433-J 4-Decade Resistor, 0-11.110 V, 0.01 V, 100 mV resolution	\$250.00
GR 1433-K 4-Decade Resistor, 0-1,110 Ohms, 0.1 Ohm resolution	\$250.00
GR 1433-L 4-Decade Resistor, 0-111,100 Ohms, 0.1 Ohm resolution	\$250.00
GR 1433-N 5-Decade Resistor, 0-11,111 Ohms, 0.1 Ohm resolution	



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TEK 7L5/L3/R7603 Spectrum Analyzer, 20 Hz-5 MHz, 10 Hz min. res., w/frame	\$1,500.00

## DISTORTION ANALYZERS

HP 339A Distortion Analyzer, built-in low distortion osc.	\$1,250.00
HP 8903A-001 Audio Analyzer, 20 Hz-100 kHz; rear panel input	\$2,000.00
HP 8903B-001,013,051 Audio Analyzer, 20 Hz-100 kHz; C-message, CCITT	\$2,500.00
TEK DA4084 Programmable Distortion Analyzer	\$1,000.00

## RMS VOLTMETERS

FLUKE 8920A True RMS Voltmeter, 180 uV-700 V, 10 Hz-20 MHz	\$450.00
FLUKE 8922A True RMS Voltmeter, 180 uV-700 V, 2 Hz-11 MHz	\$450.00
HP 209A Sine/Square Wave Generator, 4 Hz-2 MHz, 5 VRMS max.	\$225.00

## OSCILLATORS

HP 3336C Synthesizer/ Level Generator, 10 Hz-21 MHz	\$1,400.00
TEK SG501 Programmable Oscillator, 10 Hz-163.8 kHz	\$2,750.00
TEK SG502 Sine/Square Osc., 5 Hz-500 kHz, 70 dB step atten., TM500	\$200.00

## MISCELLANEOUS

HP 3575A-001 Phase-Gain Meter, 1 Hz-13 MHz, dual display option	\$850.00
HP 461A Amplifier, 20/40 dB, 1 kHz-150 MHz, 0.5 V/50 Ohms	\$125.00
KROHN-HITE 3103 High/Low Pass Filter, 10 Hz-3 MHz, 24 dB/octave	\$400.00
KROHN-HITE 3202 Dual HP/LP/BP/BR Filter, 20 Hz-2 MHz, 24 dB/octave	\$450.00
KROHN-HITE 3342R Dual HP/LP Filter, 0.001 kHz-99.9 kHz, 48 dB/octave	\$900.00
KROHN-HITE 3750 LP/HP/BP/BR Filter, 0.02 Hz-20 kHz, 6/12/8/24 dB/oct.	\$600.00
KROHN-HITE DCA-10R 10 Watt Amplifier, 20 dB gain, DC-1 MHz, 600-1000 Ohms	\$450.00
ROCKLAND 852 Dual Highpass/ Lowpass Filter, 0.1 Hz-111 kHz	\$1,000.00
TEK AF501 Tunable Bandpass Filter / Amplifier, 3 Hz-35 kHz	\$300.00
TEK AM502 Differential Amplifier, 0.1 Hz-1 MHz, TM500 series	\$475.00

## RF &amp; MICROWAVE

## SPECTRUM ANALYZERS

HP 11517A/19A/20A Mixer Set, 18.0-40.0 GHz, for HP 8555A/8569A	\$600.00
HP 11970A WR28 Harmonic Mixer, 26.5-40 GHz	\$1,100.00
HP 11970K WR42 Harmonic Mixer, 18.0-26.5 GHz	\$1,100.00
HP 11970Q WR22 Harmonic Mixer, 33-50 GHz	\$1,400.00
HP 11970U WR19 Harmonic Mixer, 40-60 GHz	\$1,400.00
HP 8444A-059 Tracking Generator, 0.5-1500 MHz, for 8554A/8568 etc.	\$1,250.00
HP 8445B Preselector, 1.8-18.0 GHz, for HP 8555A	\$650.00
HP 853A-001 Spectrum Analyzer, Display, bench/rack, mount config.	\$1,250.00
HP 8565A-100 Spectrum Analyzer, 10 MHz-22 GHz, 100 Hz min. res.	\$4,500.00
HP 8566B Spectrum An., 100 Hz-22 GHz, HP calibration certificate	\$37,500.00
HP 8569B Spectrum Analyzer, 10 MHz-22 GHz, 100 Hz min. res. bw.	\$7,500.00
TEK 7L14-039/7603 Spectrum Analyzer, 1 kHz-2.5 GHz, 30 Hz min. res. bw.	\$2,500.00
TEK TR503 Tracking Generator, 0.1-1800 MHz, for 492/4/5/6	\$850.00
TEK WM782V WR15 Harmonic Mixer, 50-75 GHz	\$1,500.00

## NETWORK ANALYZERS

HP 85021C Directional Bridge, 0.01-18 GHz, 33 dB dir, for 8755/6/7	\$1,000.00
HP 8753A Network Analyzer, 300 kHz-3 GHz	\$7,500.00

## SIGNAL GENERATORS

FLUKE 6060A Synthesized Signal Gen., 0.1-1050 MHz, 10 Hz res., GPIB	\$2,750.00
Signal Gen., 10 kHz-520 MHz, 10 Hz res., GPIB	\$1,750.00
FLUKE 6062A Synthesized Signal Gen., 0.1-2100 MHz, 10 Hz res., GPIB	\$5,000.00
GIGATRONICS 1018 Synthesized	\$4,500.00
Signal Gen., 50 MHz-18 GHz, 1 MHz res.	\$2,500.00
GIGATRONICS 600/10-18 Synthesized Source, 10-18 GHz, 1 MHz res., GPIB	\$2,500.00
GIGATRONICS 600/6-12 Synthesized Source, 6-12 GHz, 1 kHz res., GPIB	\$2,500.00
GIGATRONICS 875/50 Levelled Multiplier, x4, 50.40-50.75.0 GHz output, -3 dBm	\$2,500.00
GIGATRONICS 875/86 Levelled Multiplier, 26.40-40.0 & 50.40-50.75.0 GHz outputs	\$3,750.00
GIGATRONICS 900/2-8 Synthesized Signal Gen., 2-8 GHz, 1 kHz res., GPIB	\$3,000.00
HP 11720A Pulse Modulator, 2-18 GHz, 80 dB on/off ratio	\$450.00
HP 85100V Frequency Mult., 10-15 GHz in / 50-75 GHz out >0 dBm	\$3,750.00
HP 8640B-001,002 Signal Gen., 0.5-1024 MHz, AM, FM, var. audio osc.	\$1,750.00
HP 8656A Synthesized Signal Gen., 0.1-990 MHz, 100 Hz res., HPIB	\$2,500.00
HP 8657A-002 Signal Generator, 0.1-1040 MHz, 10 Hz res., HPIB	\$3,250.00
HP 8660C/86602B-002 Synth. Sig. Gen., 1-1300 MHz, FM / Phase mod. w/86635A	\$3,250.00
HP 8660C/86603A-002 Synthesizer, 1-2600 MHz, FM / Phase Mod., w/86635A	\$4,500.00
HP 8672A Synthesized Signal Generator, 2-18 GHz	\$6,000.00
HP 8684B Signal Generator, 5.4-12.5 GHz, AM, WBFM, Pulse	\$3,500.00

## SWEEP GENERATORS

HP 8350A/83545A-002 Sweep Oscillator, 5.9-12.4 GHz, 70 dB step attenuator	\$4,000.00
HP 8350B/83592B-002 Sweep Generator, 10 MHz-20 GHz, 70 dB step attenuator	\$14,500.00
HP 8354A RF Plug-in, 5.9-12.4 GHz, +17 dBm levelled	\$1,750.00
HP 8601A Generator/Sweeper, 0.1-110 MHz, +20 dBm levelled	\$400.00
HP 8620C Sweep Oscillator Frame	\$550.00
HP 8622B-002 RF Plug-in, 10-2400 MHz, +13 dBm levelled, 70 dB atten.	\$1,500.00
HP 8623B RF Plug-in, 1.8-4.2 GHz, +10 dBm unlevelled	\$500.00
HP 8623A-001 RF Plug-in, 1.7-4.3 GHz, +14 dBm levelled, 70 dB atten.	\$600.00
HP 8624C RF Plug-in, 3.6-8.6 GHz, +16 dBm levelled	\$700.00
HP 86241A-001 RF Plug-in, 3.2-6.5 GHz, +8 dBm levelled	\$300.00
HP 86242D-004 RF Plug-in, 5.9-9.0 GHz, +10 dBm levelled	\$300.00
HP 86250D RF Plug-in, 8.0-12.4 GHz, +10 dBm levelled	\$500.00
HP 86260A RF Plug-in, 12.0-18.0 GHz, +10 dBm unlevelled	\$500.00
HP 86260A-H04 RF Plug-in, 10.0-15.0 GHz, +10 dBm unlevelled	\$500.00
HP 86290A RF Plug-in, 2.0-18.0 GHz, +7 dBm levelled	\$1,750.00
HP 86290B RF Plug-in, 2.0-18.6 GHz, +10 dBm levelled	\$2,000.00
WAVETEK 962 Sweep Generator, 1.0-4.0 GHz, markers, +12 dBm unvlid.	\$1,500.00
WILTRON 6619A Sweep Generator, 2-8 GHz, +10 dBm levelled	\$1,500.00

## POWER METERS

ANRITSU MA72B Power Sensor, -20 to +20 dBm, 0.01-18 GHz	\$200.00
ANRITSU MP-81B/ML-83A Power Meter, 75-110 GHz (WR10), -20 to +20 dBm	\$2,500.00
BOONTON 4200-01A,03/-4A x2 Dual Channel Microwattmeter, w/(2) 1 MHz-7 GHz sensors	\$1,500.00
BOONTON 42B/41-4B Analog Power Meter, with 1 MHz-12 GHz sensor	\$375.00
BOONTON 42B/41-4E Analog Power Meter, with 1 MHz-18 GHz sensor	\$500.00
GENERAL MICROWAVE 476/4240A Power Meter & Sensor, 0.01-18 GHz, -35 to +10 dBm	\$300.00
HP 435B/8482B Power Meter, 0 to +43 dBm, 100 kHz-4.2 GHz	\$1,800.00
HP 435B/8482H Power Meter, 0.1-4200 MHz, -10 to +34 dBm	\$950.00
HP 436A Power Meter	\$900.00
HP 4874A Power Meter Calibrator, for HP 432 series	\$500.00
HP K486A WR42 Thermistor Mount	\$350.00
HP 4864A WR42 Thermistor Mount, 18.0-26.5 GHz, for 432 series	\$350.00
HP Q486A Power Sensor, 33.0-50.0 GHz, WR22, for 435/6/7/8	\$1,500.00
HP R486A WR28 Thermistor Mount, 26.5-40 GHz, for 432 series	\$350.00

## RF MILLIVOLTMETERS

BOONTON 92B-opt.05 RF Millivoltmeter, 10 kHz-1.2 GHz, 75 Ohms scale	\$500.00
RACAL 9303 TRMS Level Meter, 10 kHz-2 GHz, -77 to +23 dBm, GPIB	\$875.00

## AMPLIFIERS, MISCELLANEOUS

AMPLIFIER RESEARCH 1W1000 Amplifier, 30 dB gain, 1-1000 MHz, 1 Watt output	\$650.00
BOONTON 82AD-opt.01A Modulation Meter, AM, FM, 10-1200 MHz, GPIB	\$900.00
HP 11715A AM/FM Test Source	\$1,600.00
HP 415E SWR Meter	\$300.00
HP 465A Amplifier, 20/40 dB, 5 Hz-1 MHz, 1/2 Watt/50 Ohms	\$125.00
HP 8447A Amplifier, 20 dB, 0.1-400 MHz, 5 dB NF, +6 dBm output	\$375.00
HP 8447E Amplifier, 22 dB, 0.1-1300 MHz, +13 dBm output	\$750.00
HP 8447F Preamplifier / Power Amplifier, 0.1-1300 MHz	\$1,200.00
HP 8901A Modulation Analyzer, 150 kHz-1300 MHz	\$3,000.00
HP 8901B-1.2.3 Modulation An., 0.15-1300 MHz, rear input, OCXO, ext.LO	\$4,000.00
HP 8970A Noise Figure Meter	\$5,000.00
HUGHES 1177H02F000 TWT Amplifier, 4.0-8.0 GHz, 10 Watts output	\$1,500.00
MICROWAVE SEMI.CORP. MC5112 Noise Source, 25.5 dB ENR, 1.0-12.4 GHz, N(m), +28 VDC	\$275.00
ROHDE & SCHWARZ ESH2 Test Receiver, 9 kHz-30 MHz	\$5,000.00

## COAXIAL &amp; WAVEGUIDE

AMERICAN NUCLEONICS AM-432 Cavity Backed Spiral Antenna, LHC, 2-18 GHz, TNC(f) "NEW"	\$95.00
FXR/MICROLAB S3-02N Triple Stub Tuner, 2000-1000 MHz, 100 Watts max., N(m/f)	\$125.00
GR 874-17L Constant Impedance Trombone Line, 0-44 cm, DC-2 GHz	\$400.00
GR 900-Q GR900 14mm Interseries Adapters	\$125.00
HP 11590A-001 Bias Network, 1.0-18.0 GHz, APC7	\$450.00
HP 11612A Bias Network, 45 MHz-26.5 GHz, APC3.5	\$550.00
HP 11691D Directional Coupler, 22 dB, 2-18 GHz	\$450.00
HP 774D Dual Directional Coupler, 20 dB, 215-450 MHz	\$275.00
HP 777D-011 Dual Dir. Coupler, 20 dB, 100-2000 MHz, APC7 test port	\$450.00
HP 8431A-2-4 GHz Band Pass Filter, N(m/f)	\$175.00
HP 84	

# ELECTRONICS

## Q & A

With TJ Byers

In this column, I answer questions about all aspects of electronics, including computer hardware and software. This column doesn't replace the Tech Forum that you've grown to love and support. Instead, it will supplement it, so feel free to participate as always with your questions and answers. You can reach me on America Online at **TJBYERS**, on the Internet at **TJBYERS@aol.com**, or by snail mail at **Nuts & Volts Magazine, 430 Princeland Ct., Corona, CA 91719**.

### What's Up:

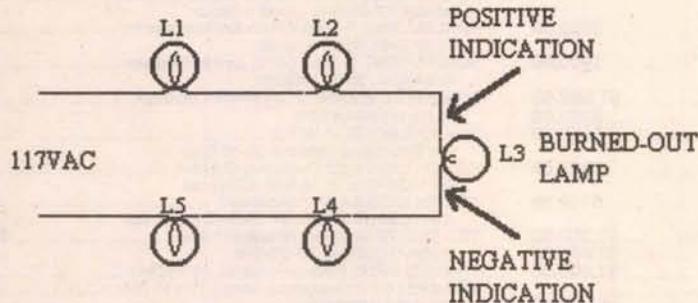
At last: Cut the Christmas burned-out bulb chase using a "magic" wand. Fun stuff: Little Nemo sleeps, simple alarm, and DTMF actuator. More serious: solar basics, MIDI interface, and a couple of power inverters (400 Hz, too). Check out the Mailbag for updates.

### Bad-Bulb Locator For The Holidays

**Q.** I'm looking for a "Handy Tester" like the one advertised in Electronic Goldmine on page 25 of your May '98 issue. Unfortunately, they were all sold out when I called and Goldmine doesn't expect to get more any time soon. Can you guide me in finding such a "tester" somewhere else and does this device really work on Christmas light strings to find the burned-out bulb?

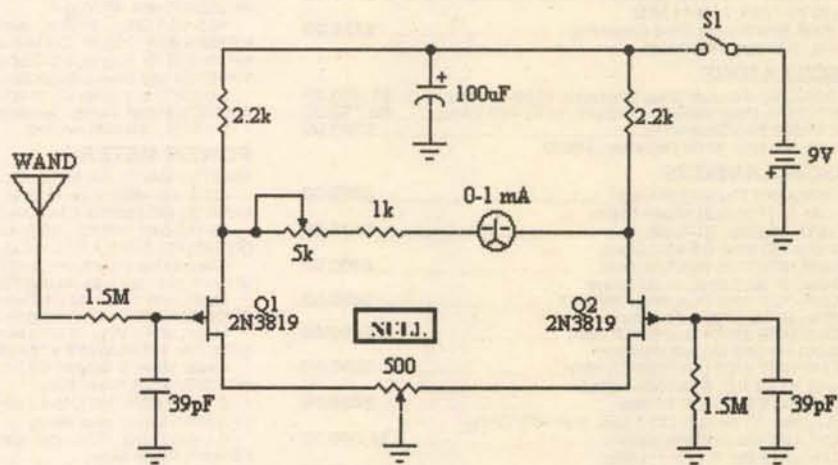
David L. Vrba  
Dublin, CA

**A.** I'm not sure what kind of sensor they used in that device, but if you're just looking for something to locate a break in an AC wire like a burned-out bulb in a Christmas light string or a bad extension cord, an electrostatic detector is just the ticket. To understand how it works, consider a string of bulbs with one burned-out bulb — an open circuit, as shown below.



The intact filaments on either side of the break (bad bulb) complete a continuous circuit from the AC supply to the opposite

sides of the broken filament. The voltage differential between wires leading to any bulb in each leg of the string is zero. However, the differential voltage across the broken filament is ground on one side and 110 VAC on the other. The presence of 110 VAC on one wire produces large electrostatic fields that are easily detected even through plastic insulation. By running an electrostatic detector (antenna) along the length of the string, the defective bulb is easily identified.



Basically, the electrostatic voltmeter is an adaptation of the original "transistorized" voltmeter, which uses two junction FETs in a balanced-bridge network. The gate of Q1 is connected to the antenna wire "wand" while Q2's gate goes to ground. The balance potentiometer sets the meter to mid scale and the gain control sets the sensitivity of the instrument. To use the tester, adjust the balance control for mid-scale reading while standing in the middle of the room. Now with the Christmas light string plugged into an AC outlet, move the wand near the lamp's wires. The needle will swing one way or the other, depending on whether it's closer to ground or the "high" AC side. You may have to adjust the gain control to keep the needle from pegging. Now slide the wand along the wiring string until you notice a definitive swing from one end of the scale to the other. The intervening lamp is the culprit and the burned-out bulb. Don't worry if there's more than one dead lamp in the string. Just keep up the procedure until all defective bulbs are found. Happy Holidays!

### Simple Alarm

**Q.** I have an EOL (End Of the Line) resistor security loop that monitors the perimeter of a storage building. It hasn't been used in a while, and I need to get it up and working again. What I need is a detector that will

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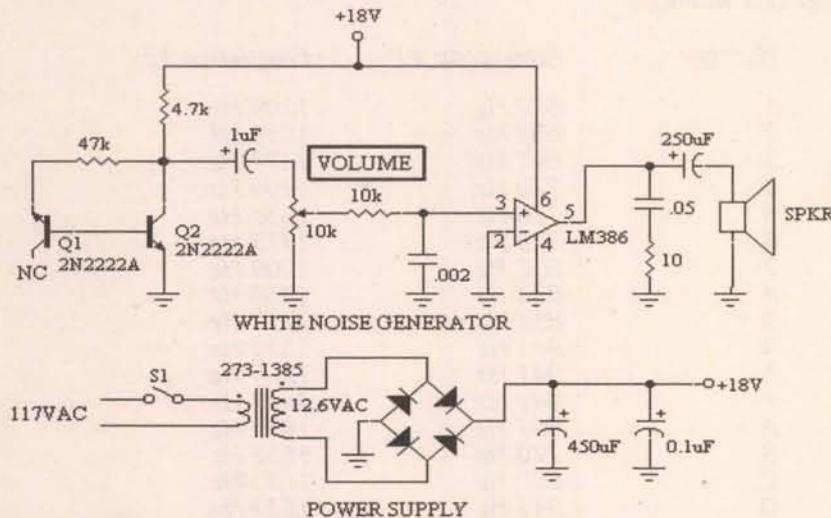
with the receiver's analog input. The tones are analyzed and output in four-bit BCD format, which is further processed by the 74LS154 4-to-16 decoder. When a legal tone combination is detected, the corresponding pin on the 74LS154 goes low — the other pins remain high.

### Little Nemo's Slumber Secret (aka White Noise)

Q. I work nights and find it difficult to sleep in the daytime. I understand that there is such a thing as a white noise generator that puts out a sound that would cancel out most of the outside noise. If you know anything about this and could tell me where to find a schematic to build one, I'd really appreciate it.

Roger  
Nashua, NH

A. Over the centuries, many methods have been tried to guarantee a good night's sleep (or day, as the case may be), everything from magical potions to bewitched poison apples to Perry Como. White noise supposedly overwhelms periodic noise sources which, in turn, blocks out unwanted sounds. Whether it works for you or not remains to be seen. Here's a way to find out.



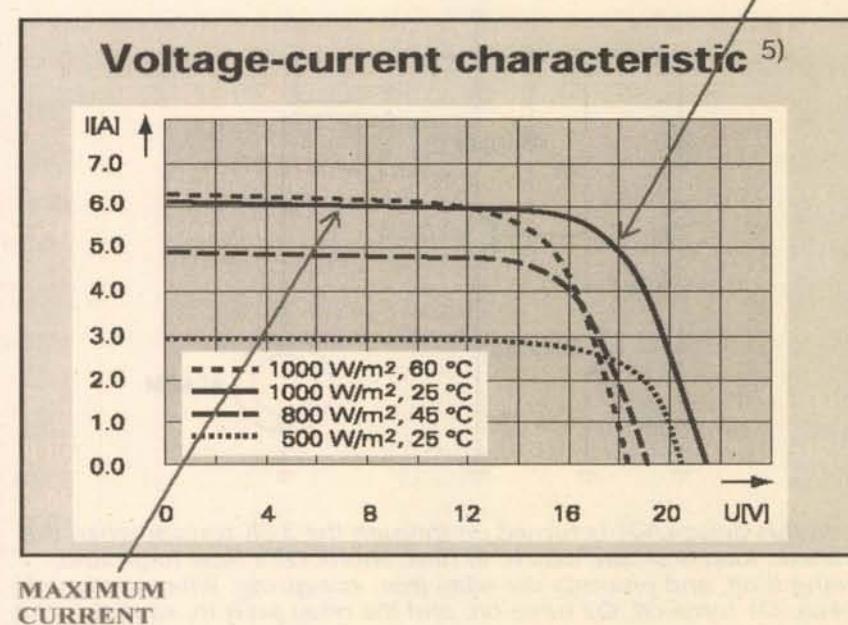
The noise is derived from a zener diode, which is made up of Q1 in the reverse-biased mode. The reversed base-emitter junction of Q1 goes into zener breakdown at about 7 to 8 volts. The zener noise is buffered by Q2 and amplified to speaker volume via the LM386 power amplifier. VOLUME controls the level of the white noise — which isn't really white noise in this design. The inclusion of the .002 uF capacitor across the input of the op amp (LM386) removes some of the high-frequency components to simulate "pink" noise, which is less harsh sounding and more soothing. Unlike white noise, which has an equal amount of energy per Hz of bandwidth, pink noise has an equal amount of energy per octave. This is done by filtering white noise with a 3 dB cut per octave as the frequency increases. Removing the capacitor restores the circuit to a full white noise spectrum. The white noise generator can be powered by two nine-volt batteries in series or the AC power supply shown. Besides providing sounds for slumber, white noise is very useful for determining the frequency response of amplifiers and other audio components. Using a spectrum analyzer or variable-frequency bandpass filter, you can map frequency peaks and valleys, but that's another story. Meanwhile, sweet dreams.

### Solar Basics

Q. I recently came into possession of (okay, I bought) two solar panels. They are surplus bought at different times from different places, but appear to be identical. They measure 12 by 12 inches and generate about 13.5 volts in full sun. My question is, how do I determine the amperage of the panels (neither has markings)? I'd like to use the panels to trickle charge a battery using the small load controller/charger you detailed in your "Solar Workshop" column a while back, but I don't know if it can be done.

Andrew L. Ayers  
via Internet

A. A solar panel is a current source, not a voltage source, as you can see below.



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### Wanted

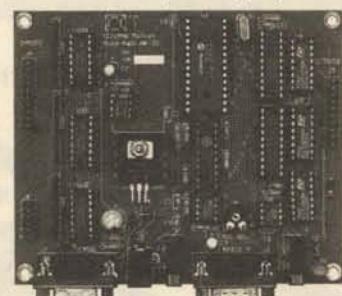
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**4 INCH LCD MONITOR \$49.00**

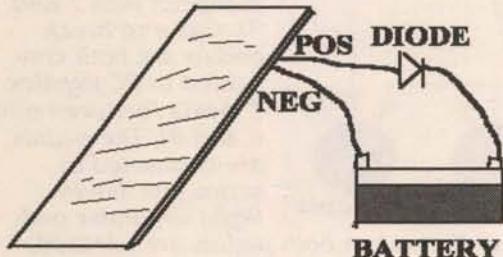
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Write in 92 on Reader Service Card.

**Electronics Q & A**

Simply place an ammeter or DMM across the panel and see how much current it outputs. Given your specs, each panel should generate about 1/2 amp, which is plenty enough to trickle charge a 12-volt marine or car battery. In fact, the current is low enough that you don't need the controller. Simply wire the two panels in parallel and connect them to the battery. A charge controller isn't needed until the charging current exceeds one-tenth (C/10) the capacity of the battery, about six amps for a typical marine battery. The diode prevents the battery from discharging through the panel at night.

**SOLAR PANEL**



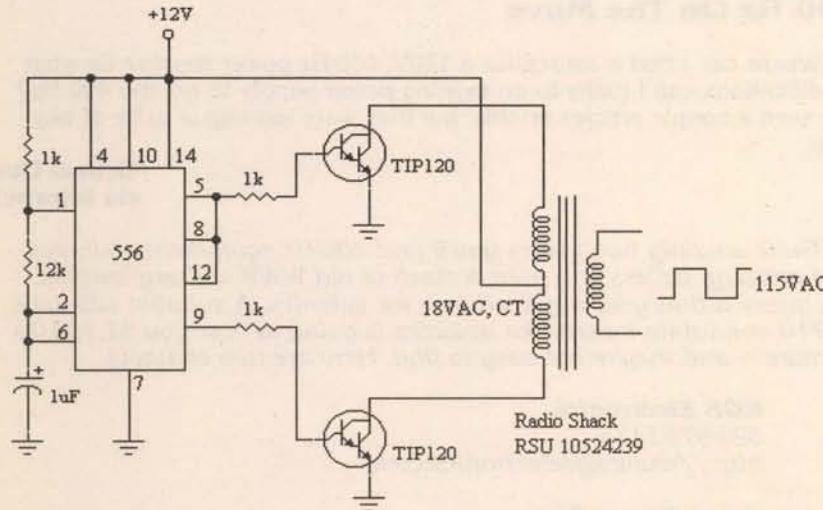
(Editor's note: Mr. Ayers got back to me, and said one panel measured 0.5 amps and the other measured 0.1 amps, which again proves that you can't judge a book by its cover.)

**Lightweight Power Inverter**

Q. I'm looking for a small 12-volt DC to 115-volt AC inverter that I can use to power an electric razor or clock radio from my car's cigar lighter. The commercial units start at about 150 watts and are overkill for what I want. Does your magic crystal ball have what I want?

T. Gifford  
 via Internet

A. Let me have a look see. Yes, the image is starting to clear now. I see ... I see this.



This low-power inverter turns 10 to 16 volts into 60-Hz, 115-volts squarewave power-to-power razors and the like up to 25 watts. The

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Unit has a backup Ni-Cd battery system in case of power failure (5 min. backup time) and lockable front cover to prevent floppy drive access. Mounting / interface provisions for standard 3.5" laptop floppy and 2.5 inch hard drives. Comes with very comprehensive manual.

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**CELL SITE TRANSCEIVER \$49.00 2 for \$99.00**

These transceivers were designed for operation in an AMPS (Advanced Mobile Phone Service) cell site. The 20 MHz bandwidth of the transceiver allows it to operate on all 666 channels allocated. The transmit channels are 870.030-889.980 MHz with the receive channels 45 MHz below those frequencies. A digital synthesizer is utilized to generate the selected frequency. Each unit contains two independent receivers to demodulate voice and data with a Receive Signal Strength Indicator (RSSI) circuit to select the one with the best signal strength. The transmitter provides a 1.5 watt modulated signal to drive an external power amplifier. Channel selection is accomplished with a 10 bit binary input via a connector on the back panel. Other interface requirements for operation are 26 VDC (unregulated) and an 18.990 MHz reference frequency for the digital synthesizer. The units contain independent boards for receiver, exciter, synthesizer, tunable front end, and interface assembly (which includes power supplies and voltage-controlled oscillator). Service manual, schematics and circuit descriptions included.

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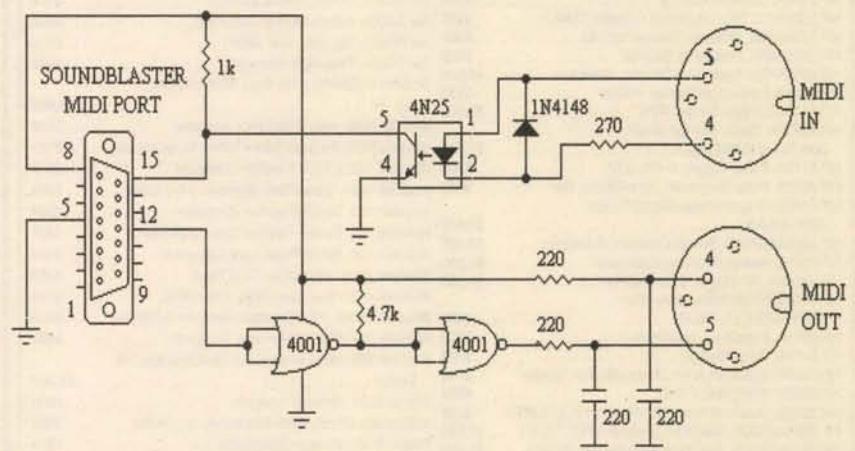
556 contains two 555 timers, one of which is wired as the master clock that oscillates at 60 Hz. The other is used as an inverter. The complimentary outputs (pins 5 and 9) are used to drive the TIP120 transistors in a push-pull mode. When pin 5 is high, pin 9 is low; when pin 5 is low, pin 9 is high. This causes the driver transistors to alternate conduction times, which forces the transformer to reverse magnetic polarity as they go back and forth. The output winding delivers an alternating squarewave of 115 VAC.

**MIDI Cable**

Q. Can you give me the wiring diagram for the MIDI cable that connects to a sound card? And if you know the diagram for steering and foot pedal controls that connect to a joystick port, that would be helpful, too.

Raymond N. Simmons  
 via Internet

A. The 15-pin joystick port on your sound card doubles as a MIDI port that allows you to communicate with external MIDI devices. For example, you could connect a Yamaha keyboard to your computer via this port and sequence your music on the PC. To do this, though, you need a MIDI adapter, like the one shown below.



This is a common item stocked by many vendors, including most music stores. Unfortunately, they sell for as much as \$79.00. The circuit above can be built for under \$10.00. The MIDI input line is isolated from the sound card's MIDI port via a 4N25 optical coupler. This is done to prevent ground loops from the MIDI instrument and the sound card, so don't be tempted to tie pin 2 of the MIDI connector (sometimes used as GND) to ground. A 1N4148 diode is reverse-connected across the optocoupler's LED input (cathode-to-anode and anode-to-cathode) to prevent damage to the LED from accidental reverse voltage and/or static discharge. The MIDI out connector is buffered by a pair of NOR gates to isolate the two. In some less expensive MIDI interface cables, the buffers are eliminated, which can cause potential damage to the MIDI port - so don't eliminate them, no matter how tempting! Here are pinouts of the SoundBlaster's game port

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HP 11664A/01, Detectors, .01-18GHz	\$200	Tek 305DMM, Scope, 10MHz, Dual Trace, DMM, battery	\$800
HP 11665B, Modulator	\$250	Tek 4041, System Controller, GPIB	\$200
HP 11712A, Service Kit for 8670 Series Inst.	\$500	Tek 436/022, Power Meter w/8481A, Cable, GPIB	\$1,200
HP 11889A, Adaptor for Plug-In 8350A/8B	\$350	Tek 464, Scope, 100MHz Dual Trace, Storage	\$400
HP 1630G, Logic Analyzer, 65 Ch, 100MHz	\$600	Tek 465, Scope, 100MHz Dual Trace	\$400
HP 16500A, Mainframe, 16510A, 16530A, 16531A	\$3,000	Tek 492/02, Spectrum Analyzer	\$4,000
16520A, 16521A	\$500	Tek 496P, Programmable Spectrum Analyzer	\$4,000
HP 16510B, Logic Analyzer Card, 16500A System	\$500	Tek 5003, Pulse Module	\$300
HP 16530A/16531A, Digital Scope Card, 16500A System	\$500	Tek 5132A, Function Generator	\$250
HP 214B, Pulse Generator	\$1,000	Tek 520N, Differential Comparator	\$100
HP 3312A, Function Generator, 1-13MHz, Sweep	\$400	Tek 520N, Differential Amp	\$100
HP 3325A, Function Generator	\$1,200	Tek 604, XY Monitor	\$100
HP 3325A/01/02, Function Gen. Opt. 01/02	\$1,800	Tek 7D20, Programmable Digitizer PI	\$600
HP 3400A, RMS Voltmeter, 10Hz-10MHz	\$200	Tek AA501, Distortion Analyzer	\$800
HP 3455A, Digital Multimeter	\$300	Tek DC503, Universal Counter Timer TM500	\$150
HP 3456A, Digital Voltmeter, 6.5 Digits	\$600	Tek DC504, Counter/Timer TM500	\$100
HP 346A, Noise Source, 10MHz-18GHz	\$500	Tek DM502A, Autoranging DMM	\$150
HP 3468A, Multimeter, 5.5 Digits	\$400	Tek FG502, Function Generator, .1Hz-11MHz	\$250
HP 3580A, Spectrum Analyzer, Opt. 02	\$800	Tek P6021, Current Probe with Termination	\$100
HP 4140B, Picomammeter, DC Source	\$2,000	Tek P6046, Differential Probe	\$300
HP 4270A, Automatic Capacitance Bridge	\$200	Tek PG508, Pulse Generator, 50MHz	\$300
HP 436A/022, Power Meter, GPIB	\$800	Tek PS503A, Dual Power Supply	\$150
HP 5004A, Signature Analyzer	\$100	Tek SC502, Scope, 15MHz, Dual Trace	\$250
HP 5005B, Signature Multimeter	\$350	Tek SC503, Scope, 10MHz Storage	\$400
HP 5006A, Signature Analyzer	\$300	Tek SC504, Scope, 80MHz Dual Trace	\$500
HP 5182A, Waveform Recorder, Generator	\$500	Tek SG502, Sig. Gen. 5Hz-50kHz	\$200
HP 5316A, Universal Counter	\$200	Tek TG501, Time Mark Generator	\$400
HP 5328A/021/040, Frequency Counter, DMM	\$250	Texscan SSG2000, Freq. Syn., 100kHz-2GHz, AM, FM	\$1,800
HP 5334A/020, Universal Counter w/DVM	\$800	Valhalla 2000, Auto Digital Watt-Ammeter	\$200
HP 5335A/010, Frequency Counter	\$800	Vu-Data 5110, Semiconductor Tester, In/Out Circuit	\$150
HP 5335A/030, Frequency Counter, 1300MHz	\$1,000	Wavetek 143, 20MHz Function Generator	\$200
HP 5340A, Frequency Counter, 18GHz	\$800	Wavetek 186, 5MHz Phase Lock Generator	\$200
HP 54100D, Digital Scope, 1GHz	\$2,000	Wavetek 1910, XY Monitor, Dual Trace	\$400
HP 54200A, Digital Storage Scope, Dual Trace, 200/MGS	\$1,000	Wavetek 452, Filter, Dual Hi/Lo, 1Hz-10kHz	\$450
HP 6112A, Power Supply, 0-40V, 0.5A	\$200	Wavetek 7530A, FFT Spectrum Analyzer 0-100kHz	\$500
HP 8015A, Pulse Generator, 1Hz-50MHz, 30V	\$500	Wavetek 907, Signal Generator, 7-11GHz	\$600
HP 8165A, Programmable Signal Source, .0001-50MHz	\$1,600	Wavetek 907, Signal Generator, 7.5-12.4GHz, AM, FM	\$1,800
HP 8350A/86290B, Sweep Oscillator, 2-18GHz	\$3,400	Wiltron 560A, Network Analyzer	\$800
HP 8350B, Sweep Oscillator Mainframe	\$2,500	Wiltron 560-97A50, SWR Autotester, .01-18GHz	\$500
HP 83545A, RF Plug-In, 5.9-12.4GHz	\$1,200	Wiltron 6100, Sweeper Mainframe	\$250
HP 8410C/8412B, Network Analyzer w/8411A/Opt. 18, 18GHz	\$800	Wiltron 610D/6237D, Sweep Generator, 2-18GHz	\$800
HP 8411A, Frequency Converters	\$250	Wiltron 6219D, RF Plug-In, 2-8GHz	\$250
HP 8414A, Polar Display	\$300	Wiltron 6223D, RF Plug-In, 7.9-18.5GHz	\$300
HP 8445B, Spectrum Anyz., Automatic Pre-Selector	\$300	Wiltron 6647A-20/02/03, Programmable Sweep Generator	\$4,000
HP 8496B, Attenuator, 110dB	\$250	Wiltron 6N5F50, Autotester, 1-1500MHz, for 640	\$100
HP 8553B, Spectrum Anyz., RF Plug-In, 1K-110MHz	\$200	Wiltron 7B50, Detector, 1-1500MHz, for 640	\$100
HP 8554B/8552B, Spectrum Analyzer 141T, 1.2GHz	\$1,500		
HP 8557A/160TR, Spectrum Analyzer, .01-350MHz	\$1,000		
HP 8559A/182T, Spectrum Analyzer, .01-21GHz	\$2,500		
HP 8559A/853A, Spectrum Analyzer, Digital, .01-21GHz	\$3,500		
HP 8565A, Spectrum Analyzer, .01-22GHz	\$20,000		
HP 8566A, Spectrum Analyzer	\$1,000		
HP 86222B/H9, RF Plug-In, .01-4GHz	\$400		
HP 86241A, RF Plug-In, 3.2-6.5GHz	\$400		
HP 86260A, RF Plug-In, 12.4-18GHz	\$400		
HP 86290A, RF Plug-In, 2-18GHz	\$1,200		
HP 86290B, RF Plug-In, 2-18GHz	\$1,400		
HP 8656B, Signal Generator, 1-990MHz, AM/FM	\$3,000		

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## Electronics Q & A

connector and five-pin MIDI connectors.

### Sound Blaster MIDI/Game Connector

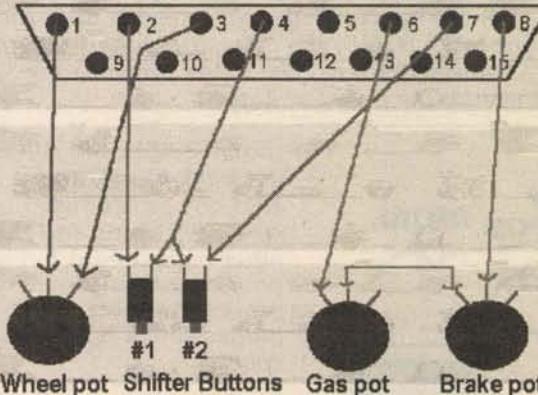
Pin	Function
1	+5V
2	X button for joystick A
3	X potentiometer for joystick A
4	GND
5	GND
6	Y potentiometer for joystick A
7	Y button for joystick A
8	+5V
9	+5V
10	X button for joystick B
11	X potentiometer for joystick B
12	MIDI out
13	Y potentiometer for joystick B
14	Y button for joystick B
15	MIDI in

### MIDI 5-pin DIN Connector

Pin	MIDI in	MIDI out
1	N/C	N/C
2	N/C	GND
3	N/C	N/C
4	Current source (+)	Current sink (-)
5	Current sink (-)	Current source (+)

Now for the second part of your question: Interfacing the joystick to the sound card's MIDI/joystick port. You specifically asked for steering and foot pedal controls, which are often used in car games. Okay, here it is.

### Male DB15 Connector (looking at the pins)



als. The connection is made so that when both the joystick interface sees about 50K of resistance. When gas is pressed (and break is kept up) the resistance increases. When the break pedal is fully pressed and gas pedal is released, the pedal's system gets the minimum resistance. This prevents you from accelerating when both the brake and gas pedals are to the metal. The shift buttons are standard PC joystick 1 buttons. For more detailed wiring diagram of steering wheels and pedals, check "Build Your Own Wheel & Pedals" article from Wally's World (<http://www.oz.net/~wottenad/>), "How To Build Rudder Pedals (for little money)" from <http://me.ritbbs.unimaas.nl/Fun/pedals/pedals.htm>, and Lew's Wheels Web page (<http://www.monmouth.com/~lw4750/index.html>).

### 400 Hz On The Move

Q. Where can I find a source for a 120V, 400-Hz power supply? Or what modifications can I make to an existing power supply to get the 400 Hz? I've seen a couple articles on this, but they were too vague to be of any help.

Michael Duc via Internet

A. There are only two places you'll find 400-Hz equipment: avionics and military. Unless you have a stash of old WWII military surplus, my guess is that your application is for avionics. A suitable 125-watt, 400-Hz solid-state inverter for avionics is going to cost you \$1,300.00 or more – and they're not easy to find. Here are two contacts.

### KGS Electronics

626-574-1175

<http://www.kgselectronics.com>

### Zzap Power Corp.

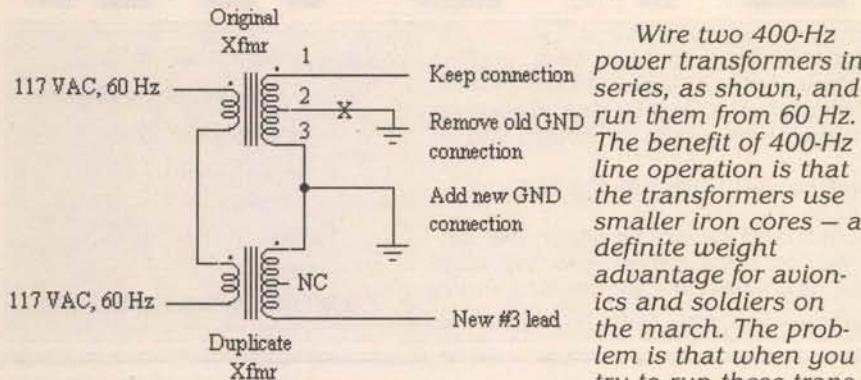
514-369-4919

<http://www.zzap.com>

## Electronics Q & A

If the power source isn't too critical, in that it can tolerate a squarewave input instead of pure sine, the circuit in the "Lightweight Power Inverter" circuit above can be modified for 400Hz operation. Simply change the value of the 1 uF capacitor to 0.15 uF. You can use the same transformer. While the frequency won't be spot on, it should be close enough for all but the most critical applications. Furthermore, you can fine tune the frequency by adjusting the value of the 12K resistor up or down.

If you're trying to power surplus old 400-Hz WWII equipment from 60 Hz, here's a trick we used back in the "old" days.



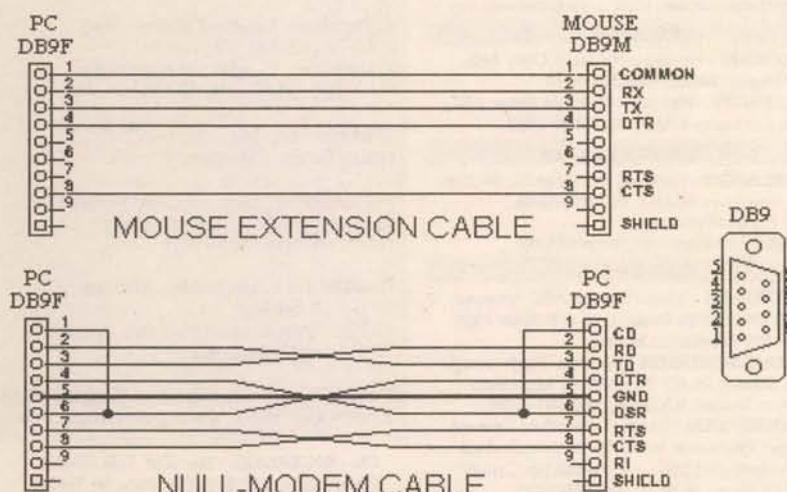
transformers off 60 Hz, they get VERY hot! By wiring two 400-Hz power transformers in series, you reduce the voltage across each by half and double the iron content. Ta-da! A working solution. The catch is you need two identical power transformers, which we used to steal from a "dead" relative of the same, and you need to find a place to mount the new transformer in the surplus device. Multiple-secondary transformers need to have this modification made for each winding. Alternatively, you might be able to find an affordable military surplus 400 Hz dynamo (motor generator) from <http://www.surplustuff.com/mic.html>.

## Not A Dumb Mouse, A Null Modem

Q. I need to add an extension to my mouse. I've tried two different extension cords, and neither works. All I got is a message saying "mouse not installed." What's up?

Anonymous via Internet

A. Even though there are many different mouse protocols and different connectors, the extension should work if it's a pass-through cable.



In essence, if pin 1 of the input goes to pin 1 of the output and pin 2 goes to pin 2, nothing changes. What I suspect is that you have a nine-pin mouse connector (DB9) that you're trying to extend using a conversion cable, like a null modem. In a null-modem cable, at least two of the wires are reversed, as shown above. Null-modem cables are plentiful and sell for about \$5.00, which is probably what you thought was an extension cable. What's a null modem cable, you ask? It lets you connect one PC to another PC using regular communications software without going through POTS (plain old telephone system) wires. Think of it as a one-on-one local area network (LAN). Extension cables (which are clearly labeled as such) are plentiful and cheap, too, but building your own has its merits. Using a couple of DPDT switches, you can even make a universal extension/null-modem cable as one. Think about it. Quiz on Monday.

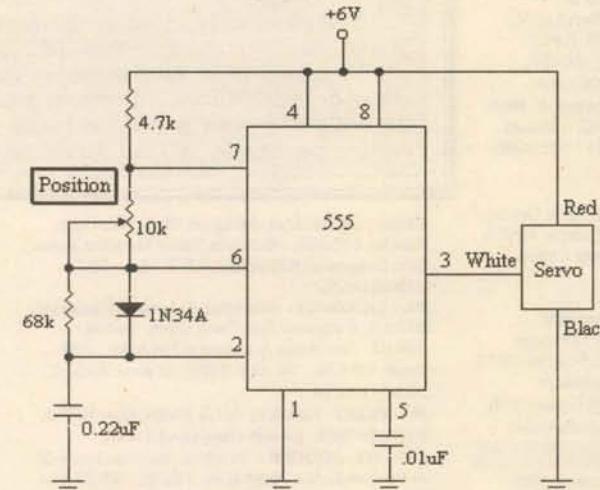
## Servo Controllers ... Again

Q. I was wondering if I could ask you about the "Simpler Servo Controller" in the Oct. '97 issue? I've constructed this circuit several times, and tried it with a variety of servos. Although the servo hums (indicating a pulse is

coming through), it doesn't move, and after a short while the 555 heats up. I'm using a regulated five-volt power supply to drive the circuit. Do you know if this circuit actually works? I've seen other circuits on the Web that claim to control servos, but only vary frequency, not pulse width. I have managed to control servos using circuits I've found on the Internet, but they only provide about 45 degrees of rotation. There has GOT to be a simple servo controller circuit out there that works! Any idea where I can get one? I've been searching like mad.

Walt Noon via Internet

A. I never built the circuit that the reader submitted in the Reader's Tip section of that issue, but it should work. You might want to play with the values of the 39K and 220K resistor to fine tune the response timing. Meanwhile, here's a circuit that I have built and tested – and it works.



The pulse width varies between 1 ms and 2 ms for the left and right extremes, which can span anywhere from 160 degrees to 270 degrees, depending on the servo; a 1.5 ms pulse centers the sweep. The width of the pulse is adjusted by the 10K Position potentiometer. This pulse repeats every 20ms, for a repetition rate of about 50 Hz (servos typically operate between 20

Hz and 80 Hz). The 1N34A is a pulse-shaping diode that sharpens the fall time. The red and black servo leads are power, and the white lead from the servo is the control lead. Have fun!

## MAILBAG

Dear TJ Byers:

About the LM558 timer IC in the Sept. '98 column, this chip may be "long obsolete" but there are many uses for this timer. It's available through **Tech America (1-800-877-0072; <http://www.techam.com>)** for just \$0.87. You can find typical applications for this chip in the *Radio Shack Engineer's Notebook II* on pages 102 and 103. I hope Phil Clock and other experimenters can use this information.

Raymond Sylvester  
North Branford, CT

Response:

Yes, rumors about the death of this chip are premature. **Philips Semiconductor (1-800-234-7381; <http://www.semiconductors.philips.com>)** still makes them under the name NE558N. You can download the NE558 data sheet from **QuestLink (<http://www.questlink.com>)** and order the part from their Engineer's SuperStore on the Web site.

TJ Byers  
Q & A Editor

Dear TJ:

After reading your answer to "Ring Me Up Sometime" I thought that you might like a possible answer to the secret number for calling oneself back. In our area, northern California, we simply call our own seven-digit phone number and get a busy signal. We then hang up and about five seconds later the phone company rings us back. We use this method as an intercom and I believe it's free. Our phone repair person freely told us about this method, and I believe you can call a phone representative and get the same answer if you just ask.

Chris Bieber, CA

Response:

I've received several letters like this from across the country, and I'm sure it works for many locations. It certainly worked when I lived in southern California. However, it won't work if you have voice mail or call waiting. I now live in northern California, but when I called my local representative (Pac Bell) and repair service (611) about a callback service before answering the reader's question, they denied its existence. Fortunately, my Telecom repair lady (cable, not Pac Bell) knew the number and was more than willing to spread the word. So much for a kinder, gentler phone company.

TJ Byers  
Q & A Editor

# Events

DECEMBER 1998

DECEMBER 5

**AL - DOTHAN** - Hamfest. Wiregrass ARC, Cheryl Tucker KD4BWE, 334-677-7485

**CA - SANTEE** - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052

**FL - OKEECHOBEE** - Hamfest. Okeechobee ARC, Al Berryman AD4RZ, 941-467-0516. E-Mail: ad4rz@juno.com

**GA - CLAXTON** - Hamfest. Veterans Community Center, Hwy. 280 W. VE Exams. Talk-in: 147.075+. Claxton AR Emergency Service, Mr. Ellie Waters WB4CJB, 912-653-4939. E-Mail: ellie@premierweb.net. Wes Kennedy KU4SR, 912-739-2047. E-Mail: ku4sr@mci2000.com

**IL - JACKSONVILLE** - Hamfest. Turner Jr. High School. VE Exams. Jacksonville ARS & Illinois Valley ARC, Tim Childers KB9FBI 217-245-2061. E-Mail: kb9fbi@fqi.net

Web: <http://www.qsl.net/k9jx>

**LA - MINDEN** - Christmas Hamfest. Civic Center, 520 Broadway. 8:30am-3pm. VEC Exams. MARA repeater 147.300+. MARA, Inc., Dusty Collins KB5WFE, 318-371-0636.

E-Mail: dustyc@prysm.net

Web: <http://www.norwesla.com/mara.htm>

**MN - GOLDEN VALLEY** - Hamfest. Courage Handi-Ham System, Nancy Meydell, 612-520-0512

**NC - GREENSBORO** - Hamfest. Coliseum

Special Events Center. 9am-3pm. 76 Group, 336-851-1676. <http://www.sabwc.com/gsophamfest>

DECEMBER 6

**CA - LIVERMORE** - Hamfest. Livermore ARK, Cliff Kibbe KF6ELL, 209-835-6715. E-Mail: larkswap@hotmail.com

DECEMBER 12

**CA - FONTANA** - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves

**FL - LAKE CITY** - Hamfest & Computer Show. Columbia County Fairgrounds, SR 247, Gateway to FL #4. Columbia ARS, Joe Aymond WD4EOJ, 904-935-2405 6-10pm, E-Mail: wd4eoj@isgroup.net or Colin Boutwell WA5RKR, 904-755-7960, E-Mail: wa5rkr@isgroup.net

**SC - UNION** - Hamfest. National Guard Armory, Industrial Park Rd. 8am-2pm. Talk-in: 145.250- Union County ARC, Roger Gregory KI4RG, 864-427-1462. E-Mail: rgregory@carol.net

DECEMBER 19

**CA - SANTEE** - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052

## JANUARY 1999

JANUARY 2

**CA - SANTEE** - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052

**TM - MORRISTOWN** - Hamfest & Computer Show. Tally Ward Recreation Bldg. Talk-in: 147.303+ & 53.030-. Lakeway AR, Perry Hensley N4PH, 423-828-4848 E-Mail: n4ph@juno.com. Kemp Lawson KF4AGB, 423-587-3320. E-Mail: kemplawson@aol.com. Web: <http://www.usit.net/mfawbush/larc.html>

JANUARY 9

**CA - FONTANA** - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves

**CO - LOVELAND** - Superfest. Larimer County Fairgrounds, 700 Railroad Ave. 9am-3pm. VE Exams. Talk-in: 145.115 or 146.85. Northern CO ARC, 970-352-5304

**NY - MARATHON** - Hamfest. Skyline ARC, Patrick Dunn KC2BQZ, 315-468-5909

**SC - GREENWOOD** - Hamfest & Computer Show. Greenwood Civic Center, 1610 Hwy. 72 E. 9am-5pm. FCC exams. Talk-in: 147.165+ (open) alternate: 146.52 simplex. Greenwood ARS, Frank Kolar WA9FWO, 864-229-5639. Web: <http://www.w4gdw.org>

**WI - WAUKESHA** - Hamfest. Waukesha County Expo Center Forum. 8am-2pm. West Allis RAC, Phil Gural W9NAW, 414-425-3649

JANUARY 9-10

**FL - FT. MYERS** - Hamfest. Sat: 9am-3pm, Sun: 9am-2pm. Talk-in: 146.880. Ft. Meyers ARC, Colleen Sammons KQ4TR, 941-936-1431. E-Mail: csammons@juno.com

JANUARY 10

**IN - SOUTH BEND** - Hamfest. The Century

# CALENDAR

The Events Calendar is a free service for publicizing electronic events such as amateur radio hamfests, flea markets, etc. If your organization is sponsoring an event and would like a free listing, contact us at least 60 days in advance. Include your flyer, estimated attendance, name of the person to contact, and phone number.

Complimentary issues are available upon request for distribution to your attendees. A street address for UPS is required.

While we strive for accuracy in our calendar, we can not be responsible for errors or cancellations. The information contained in this column is for the use of the readers of *Nuts & Volts* and may not be republished in any form without the written permission of T & L Publications, Inc.

All listing information should be sent to:

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**Events Calendar**

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**Fax** 909-371-3052

**E-mail** events@nutsvolts.com

## COMPUTER SHOWS

**AGI Shows**, 317-299-8827.

E-Mail: info@agishows.com

<http://www.agishows.com>

**Blue Star Productions**

612-788-1901

<http://www.supercomputersale.com>

**Computers And You**, 734-283-1754.

[www.al-supercomputersales.com](http://www.al-supercomputersales.com)

**Computer Central Shows**

847-412-1900 & 1-888-296-6066.

E-Mail: compcent@megsinet.net

[www.computercentralshows.com](http://www.computercentralshows.com)

**Five Star Productions**

810-890-0988 E-Mail: jeff@fivestar

[www.fivestarshows.com](http://www.fivestarshows.com)

**Georgia Mountain Productions**

706-838-4827.

E-Mail: gamtnpro@blrg.tds.net

[georgiamountain.com](http://georgiamountain.com)

**Gibraltar Trade Center, Inc.**

734-287-2000. Taylor, MI.

**Gibraltar Trade Center, Inc.**

810-465-6440. Mt. Clemens, MI.

**MarketPro, Inc.**, 201-825-2229

<http://www.marketpro.com>

**MarketPro, Inc.**, 301-984-0880.

E-Mail: md@marketpro.com

<http://marketpro.com>

**Northern Computer Shows**

978-744-8440

E-Mail: inquiries@ncshows.com

[ncshows.com](http://ncshows.com)

**Peter Trapp Computer Shows**, 603-272-5008. Web: [www.petertrapp.com](http://www.petertrapp.com)

**OR - RICKREALL** - Hamfest. Polk County

Fairgrounds, 520 S. Pacific Hwy. W. Talk-in: 146.86-. Salem Repeater Assn. and Oregon Coast

Emergency Repeater, Evan Burroughs N7IFJ, 503-585-5924 before 8pm.

E-Mail: n7ifj@teleport.com

<http://sra.goldcom.com/sraflyer.htm>

**FEBRUARY 21**

**MI - FARMINGTON HILLS** - Swap 'n Shop.

William M. Costick Activities Center, 28600

Eleven Mile Rd. 8am-3pm. Talk-in: 145.350-

repeater and 146.52 simplex. Livonia ARCS, 734-261-5486. E-Mail: swap@larc.mi.org

[www.larc.mi.org](http://www.larc.mi.org)

**NC - ELKIN** - Hamfest. Briarpatch & Foothills

ARCS, Jimmy Holbrook KB4GKI, 336-957-3820.

E-Mail: kb4gki@aol.com Web:

<http://members.aol.com/kb4ghi/kb4gki.html>

**FEBRUARY 22**

**KY - CAVE CITY** - Hamfest. Mammoth Cave

ARC, 502-651-2363. E-Mail: lbrummett@glasgow

ky.com Web: <http://www.scrct.blue.net/mcarc>

**VT - MILTON** - Convention. RAs of Northern VT,

Mitch Stern W1SJ, 802-879-6589. E-Mail:

<http://www.ranv.together.com>

**CA - SANTA ANA** - Swapmeet. ACP parking lot. Mary Russo 714-558-8813

**MD - ODENTON** - Hamfest. Maryland Mobileers

ARC, Bill Ziegler KA6TY, 410-987-2384.

E-Mail: ka6ty@juno.com

## FEBRUARY 1999

FEBRUARY 6

**AR - WEST MEMPHIS** - Hamfest. Dixie AR Group, Kellye Farris KB5RCE, 870-732-8724.

E-Mail: kb5rce@media-two.com

Web: <http://www.media-two.com/DARG>

**CA - SANTEE** - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052

**SC - NORTH CHARLESTON** - Hamfest. Stall

High School. 8:30am-4pm. VE Exams. Charleston ARS, Jenny Myers WA4NGV, 843-747-2324.

E-Mail: brycemyers@aol.com

FEBRUARY 6-7

**FL - MIAMI** - Tropical Hambooree. Fair Expo Center, S.W. 112th Ave. & Coral Way. VE Exams. Talk-in: 146.925, 146.76, 444.525, Dade Radio Club of Miami, Evelyn Gauzens, 305-642-4139, E-Mail: edg@elink.net. 305-226-5346, E-Mail: wd4sfg@bellsouth.net. Web: [www.hambooree.org](http://www.hambooree.org)

FEBRUARY 7

**OH - LORAIN** - Hamfest. Northern Ohio ARS, Mike Willemin W8EU, 440-324-4574

**PA - LATROBE** - Hamfest. Chestnut Ridge ARC, William Demosky K3AFS, 724-539-1552

FEBRUARY 12-13-14

**FL - ORLANDO** - Hamfest. Northern FL Section Conv., Tim Starr AE4NJ, 407-850-9258.

E-Mail: AE4NJ@aol.com

Web: <http://www.oarc.org/hamcat.html>

FEBRUARY 13

**CA - FONTANA** - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves

**MA - MARLBOROUGH** - Hamfest. Marlborough Middle School, Rt. 85. 10am-2pm. Algonquin ARC, Ann Weldon KA1PON, 508-481-4988

**NY - WESTFIELD** - Hamfest. Westfield Exempt Volunteer Fireman's Assn., 75 Bourne St. 8am-3pm. Talk-in: 145.350 (-). Chautauqua County RAs, Eric Kroon N2PCQ, 716-595-3220.

E-Mail: ekroon@netsync.net

FEBRUARY 14

**OH - MANSFIELD** - Mid\*Winter Hamfest &

Computer Show. Richland County Fairgrounds.

Talk-in: call W8WE on 146.34/94. InterCity ARC, Inc., Pat Ackerman N8YOB, 419-589-7133 after 2pm EST.

FEBRUARY 20

**AR - RUSSELLVILLE** - Hamfest. AR River Valley AR Foundation, Margaret Alexander KC5MCS, 501-968-7270. E-Mail: ealexand@cswnet.com

**CA - SANTEE** - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052

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Post 10209, Spring Hill Dr. between US 41 &

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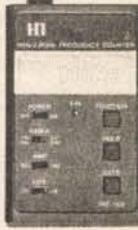
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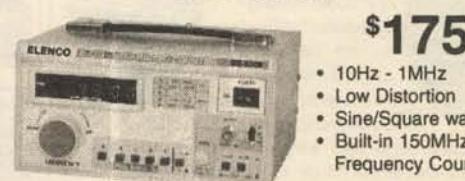
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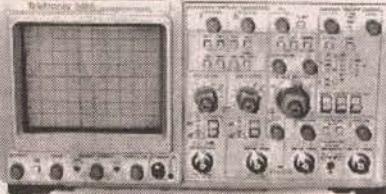


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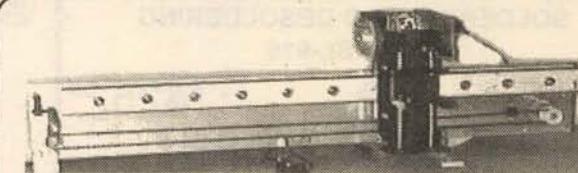
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# ELECTRONIC CIRCUIT SYMBOLS & NOTATIONS

by Ray Marston

**Ray Marston looks at some controversial aspects of modern circuit symbology in this special feature article.**

## INTRODUCTION

Back in May '97, I started writing regular 'circuit application' feature articles for *Nuts & Volts* magazine. All of these articles are specifically aimed at experienced design engineers and competent electronics enthusiasts (rather than at novices or complete beginners), and are unusual in two special respects.

They are unusual, first, because most of them carry (on average) about 20 illustrations or practical circuit diagrams, and second, because all of the circuit diagrams use International style — rather than US Customary — circuit symbols and component notations.

All of these articles have been well received by most *Nuts & Volts* fans, but some readers (who admit to being electronics novices) have complained that they are quite bemused by the component notations that I use in these articles. I suspect that quite a few other *Nuts & Volts* fans may feel the same way so, in this special article, I aim to explain the operation of the International style electronic circuit diagram system, and to explain the system's advantages over the US Customary system. This is a fairly controversial subject and may annoy some readers, so I will start off by presenting my qualifications for writing about it, as follows:

## MY QUALIFICATIONS

I have been an electronics design engineer and writer/author for over 30 years. During that peri-

od, I have — amongst other things — been editor or technical editor of four different electronics magazines, have written about 2,000 technical articles, and have written 31 electronics engineering books. Many of my magazine articles are published internationally, and — in various periods — have appeared regularly in magazines in the UK, Germany, Holland, Australia, Canada and the USA.

Of my 31 books, two were first published in Germany, and the rest in the UK; several were later published in the USA. Between them, these books have been translated into about a dozen different languages (often with suitably modified circuit diagrams), including Russian, Hindustani, and most major European tongues.

Throughout the past five years, I have produced most of the artwork and circuit diagrams that accompany my books and magazine articles (including those used in *Nuts & Volts*), using a *Corel DRAW 3* artwork/CAD package and my private symbols library. I generate an average of about 350 diagrams a year, and have thus produced about 1,750 technical

illustrations and diagrams in the past five years.

As a consequence of all the above, I have lots of professional experience in the technical publishing business and in generating modern circuit diagrams, and am familiar with many of the different electronic circuit symbol and notation systems that are used in various parts of the world and with their specific advantages and disadvantages compared to other systems.

## TYPICAL CIRCUIT DIAGRAMS

In the western world, most major industrial countries have their own individual preferred styles for electronic circuit symbols and notations, but these styles are not too rigidly applied and often vary considerably between one technical publisher and another, according to the 'house style' of the individual publishing company. In the USA, for example, the so-called 'US Customary' system is normally used, but the precise details of the system vary significantly between different electronics magazines.

Figures 1 to 5 show examples

of how exactly the same circuit diagram can vary when published by particular electronics magazines in particular parts of the western world. The circuit is that of a simple LM386 audio power amplifier, with its voltage gain set at x200 by C4 and with its output protected by the C3-R1 Zobel network and loaded by an eight-ohm speaker.

Figure 1 shows the diagram drawn using the familiar US Customary system, using the basic house style of *Electronics Now* magazine, and Figure 2 shows the same diagram drawn in the house style of the German electronics magazine *Elrad*, which uses a simple rectangular symbol (rather than a zig-zag) to represent a resistor.

Regarding the German capacitor symbols, the two parallel lines used to represent C1 and C3 indicate that these are ordinary non-electrolytic components, and the black and white rectangles used to represent C2 and C4 indicate that these are electrolytic capacitors; the '+' signs associated with C2 and C4 indicate that the capacitors are polarized types, and that the white terminal is positive.

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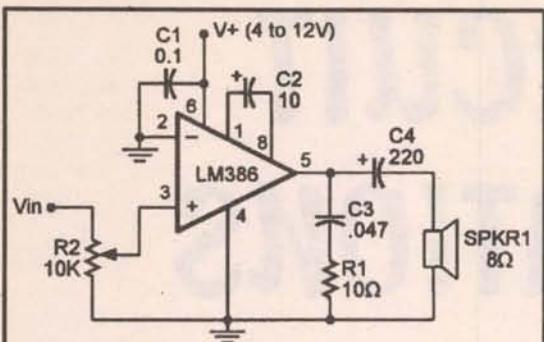


Figure 1. Circuit in the house style of *Electronics Now* magazine (USA).

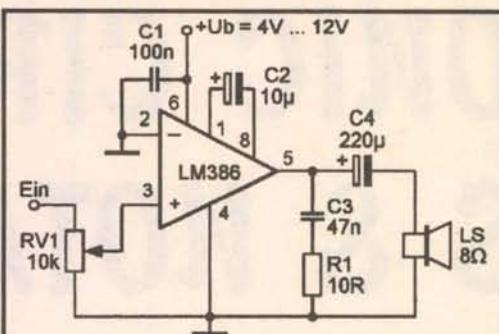


Figure 2. Circuit in the house style of *Elrad* magazine (Germany).

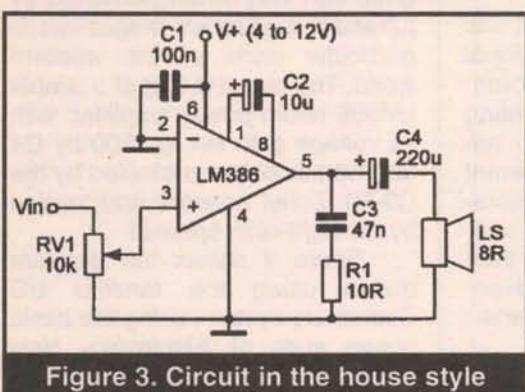


Figure 3. Circuit in the house style of *Electronics Today International* magazine (UK).

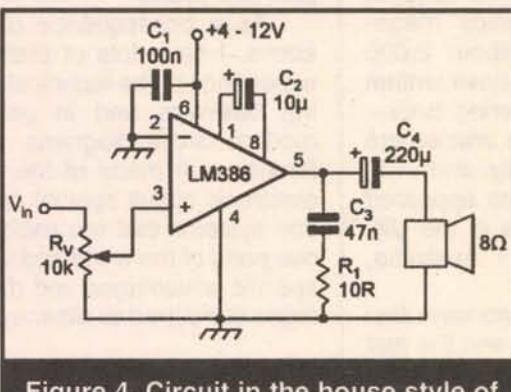


Figure 4. Circuit in the house style of *Electronics World* magazine (UK).

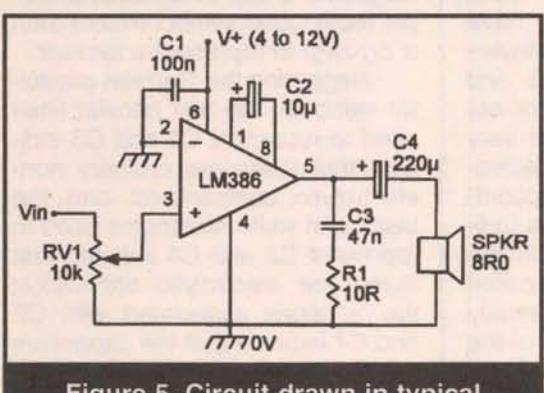


Figure 5. Circuit drawn in typical International style.

magazine sales are dominated by six popular titles. Half of these use the zig-zag resistor symbol in their circuit diagrams, and half use the simple rectangular symbol. Figure 3 shows the Figure 1 diagram redrawn in the house style of one of the most popular British electronics magazines, *Electronics Today International*, which uses the simple rectangle to

drawn in my own particular version of the International circuit diagram style (which I use in my *Nuts & Volts* articles), in which resistors are drawn as zig-zags, capacitors are in simplified European style, and component values are given in formal 'International' style, which is explained in a later major section of this article.

Note in Figures 1 to 5 that all five basic diagrams are quite easy to understand, in spite of the variations in the styles of the symbols used to represent resistors, capaci-

tors, ground points, and loudspeakers. Also note that the variable resistor is notated by RV (Resistor, Variable) in the four non-US diagrams, but by a simple R in Figure 1. Finally, note that the Figure 2 to 5 diagrams use a plain R instead of the symbol to indicate a resistor's value in ohms, and (in Figures 2 and 4) use the symbol only to indicate the loudspeaker's nominal impedance value.

The most prestigious British electronics magazine is *Electronics World*, which is aimed directly at professional engineers and managers; it has its own basic house style for circuit diagrams, but varies the style slightly from article to article. Figure 4 shows Figure 1 redrawn in this magazine's basic house style; note the awkward mixture of upper-case and subscript characters used to denote component numbers, etc.

Finally, Figure 5 shows Figure 1

to 5 circuits are analog designs. Foreign digital designs can be far harder to understand. Figure 6, for example, shows some of the crazy official symbols used to represent simple logic gates in Europe. In practice, most European electronics book and magazine publishers sensibly adhere to the American MIL/ANSI symbol system, which is also used in the normal 'International' diagram system.

For most American readers, the only problems presented by the non-US Figure 2 to 5 diagrams relate to the International component value notation systems that they use, which all notate the 10 resistor as 10R, and notate 0.047μF capacitor C3 as 47n (the odd 220u — rather than 220μ — notation used on C4 in Figure 3 is simply a house style peculiarity used by one UK magazine). Before explaining how the International notation system works, I will explain why it was developed.

## EVOLUTION OF THE 'INTERNATIONAL' SYSTEM

Prior to the mid 1970s, the electronic component notation systems used by most European countries were similar to the present US Customary system and were loosely based on the metric scientific notation system that — in 1960 — became officially known as SI (Système Internationale d'Unités).

In the 1960s, however, major developments in the semiconductor industry resulted in a great increase in the complexity of practical circuit designs, and industry and commerce began looking for ways of producing the resultingly complex circuit diagrams and literature with greater efficiency.

Matters reached a historic peak in 1975 when the British Standards Institute (BSI) published — after a very long period of study and consultation — a list of recommendations concerning this subject.

Many of the 1975 BSI recommendations — particularly those relating to the use of new digital circuit symbols — were pretty stupid, and were rejected by most of the electronics industry, but those relating to an international system of electronic component-value notation were excellent, and were soon adopted by most of the world's industrial nations, with the notable

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This new notation system was, in effect, an improved and streamlined version of the existing SI-based system, and was thus quite easy to learn. When its basic form was first specified, it was required to be designed as a simple easily-printed code that indicates an electronic component's value clearly, briefly, without ambiguity, and with a minimum loss of clarity if poorly printed.

This last requirement immediately ruled out the use of decimal points in the new code system, and the requirement for brevity called for (1) the elimination of all superfluous information from the code, and (2) for sensible compression of the remaining data.

Regarding point (1) in the 'brevity' requirement, note that in circuit diagrams, when indicating the value of a symbolic resistor, capacitor, or inductor, it is self-evident that the component's value is expressed in basic units of ohms, Farads, or Henrys, and the new code's design specification thus demanded the elimination of this superfluous 'postscript' data from the printed code *when used in circuit diagrams* (but not necessarily in normal printed text).

Regarding point (2) in the 'brevity' requirement, this was to be aided by using a fixed three-decade spacing between the decimal 'multiplier' units used to indicate a component's value.

Figure 7 lists the range of decimal multiplier units — using basic SI scientific notation and three-decade spacing — that are normally used in electronics, together with their normal prefixes, etc., and Figure 8 shows how they are applied in the modern US Customary notation system (which was also widely used in pre-1975 Europe).

Note in Figure 8 that the US Customary system uses three-decade multiplier spacing when notating values of resistance, inductance, frequency, and time, but inexplicably uses six-decade spacing (between  $\mu$ F and pF) when notating values of capacitance. This six-decade spacing is a major cause of the cumbersome capacitance-value notations (such as  $0.001\mu$ F) that often appear in US circuit diagrams.

These, then, were the basic ideas behind the creation and development of the 1975 BSI component notation system, which today is known as the 'International' system. Let's now look at the details of the modern version of this system.

Logic function	American (MIL/ANSI) Symbol	British (BS3939) Symbol	Common German Symbol	International Electrotechnical Commission (IEC) Symbol
Buffer	IN OUT	IN OUT	IN OUT	IN OUT
Inverter (NOT gate)				
2-input AND gate				
2-input NAND gate				
2-input OR gate				
2-input NOR gate				
2-input EX-OR gate				
2-input EX-NOR gate				

Figure 6. A selection of widely used logic symbols.

## THE 'INTERNATIONAL' SYSTEM

### RESISTANCE NOTATION

The standard unit of resistance

is the ohm, named after a Bavarian, George Simon Ohm who, in 1827, published the results of his research into electrical resistance and whose name is commemorated by the symbol  $\Omega$

(omega), which is the Greek equivalent of the Bavarian letter  $\ddot{O}$ . In 1975 (prior to the advent of the wordprocessor and CAD drawing), the symbol  $\Omega$  was not carried on normal typewriters and was time-consuming to produce using normal drawing techniques.

Consequently, in 1975, the BSI recommended that the symbol  $\Omega$  should no longer be used on circuit diagrams as a postscript when denoting resistance values, that units of resistance should be notated by the capital letter R, that thousands of units be notated by the lower-case letter k (for kilohm), and millions of units be notated by the uppercase letter M (for megohms). Thus, in this system,  $47\Omega$ ,  $47k\Omega$ , and  $47M\Omega$  become  $47R$ ,  $47k$ , and  $47M$ .

### CAPACITANCE NOTATION

The standard unit of electrical capacitance is the Farad, represented by the symbol F. In electronics, the Farad is too large a unit for general use and, prior to 1975, most capacitors had values that were expressed in units of a millionth of a Farad ( $\mu$ F) or a millionth of a millionth of a Farad ( $\mu\mu$ F). Thus,  $1\mu$ F equals 1,000,000pF. This six-decade space between basic multiplier units obviously results in excessively long component notations, and BSI recommended that this problem be eliminated.

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Prefix	Symbol	Multiplier
giga	G	10 <sup>9</sup>
mega	M	10 <sup>6</sup>
kilo	k	10 <sup>3</sup>
(unit)	(unit)	10 <sup>0</sup>
milli	m	10 <sup>-3</sup>
micro	μ	10 <sup>-6</sup>
nano	n	10 <sup>-9</sup>
pico	p	10 <sup>-12</sup>

Figure 7. Decimal multiplier scientific notations.

Multiplier	R	C	L	f	Time (seconds)
10 <sup>9</sup>	—	—	—	G	—
10 <sup>6</sup>	M	—	—	M	—
10 <sup>3</sup>	k	—	—	k	—
10 <sup>0</sup>	Ω	F	H	Hz	s
10 <sup>-3</sup>	m	—	m	—	m
10 <sup>-6</sup>	—	μ	μ	—	μ
10 <sup>-9</sup>	—	—	—	—	n
10 <sup>-12</sup>	—	p	—	—	p

Figure 8. Multiplier symbols used in the US Customary notation system.

Multiplier	R	C	L	f	Time (seconds)
10 <sup>9</sup>	—	—	—	G	—
10 <sup>6</sup>	M	—	—	M	—
10 <sup>3</sup>	k	—	—	k	—
10 <sup>0</sup>	R	F	H	Hz	s
10 <sup>-3</sup>	m	—	m	—	m
10 <sup>-6</sup>	—	μ	μ	—	μ
10 <sup>-9</sup>	—	n	—	—	n
10 <sup>-12</sup>	—	p	—	—	p

Figure 9. Multiplier symbols used in the International notation system.

inated by reducing the spacing between multiplier units to three decades, by introducing a unit known as the nano-farad (fully notated as nF), and equal to 1000pF. Thus, 1nF equals 0.001μF, and 1000nF equals 1μF.

In circuit diagrams, when indicating the value of a capacitor, it is self-evident that the component's value is expressed in Farads, and it is thus superfluous to re-state the fact in the diagram.

Consequently, the BSI recommended that, for component notation purposes, the symbol F should no longer be used on circuit diagrams as a postscript

when denoting capacitance values, and that the scientific symbols μ, n, and p be used as basic multiplier

units. Thus, in this system, 4,700μF, 47μF, 0.047uF, and 47pF become 4,700μ, 47μ, 47n, and 47p.

Component number	U.S. Customary	International style
C1	22pF	22p
C2	0.001μF	1n0
C3	0.01μF	10n
C4	0.047μF	47n
C5	.1μF	100n
C6	1μF	1μ0
C7	470μF	470μ
R1	8Ω	8R0
R2	220Ω	220R
R3	1.2kΩ	1k2
R4	4.7k	4k7
R5	100k	100k

Component number	U.S. Customary	International style
C1	22pF	22p
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C4	0.047μF	47n
C5	.1μF	100n
C6	1μF	1μ0
C7	470μF	470μ
R1	8Ω	8R0
R2	220Ω	220R
R3	1.2kΩ	1k2
R4	4.7k	4k7
R5	100k	100k

Figure 10. A selection of US Customary notations and their International system equivalents, reproduced at 100%, 77%, 66%, and 50% scales.



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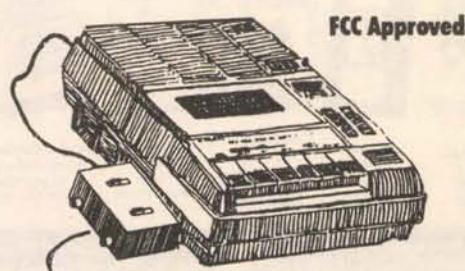


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## INDUCTANCE NOTATION

The standard unit of electrical inductance is the Henry, represented by the symbol H. In circuit diagrams, when indicating the value of an inductor, it is self-evident that the component's value is expressed in Henrys, and it is thus superfluous to re-state the fact in the diagram. Consequently, in 1975, the BSI recommended that — on circuit diagrams — the capital letter H should only be used to note actual units of inductance, that thousandths of units be noted by the lower-case letter m (= millihenry), and millionths of units be noted by the symbol μ (= microhenry). Thus, in this system, 47H, 47mH, and 47μH become 47H, 47m, and 47μ.

## DECIMAL POINTS

Decimal points sometimes become so severely degraded during the printing process that they cease to have a final practical value. As an example of this process, take the case of the decimal point associated with C1 in Figure 1. I originally generated this diagram in Corel DRAW vector format, with the C1 notations set in Arial text at 10-point size, under which conditions the decimal point takes the form of a 0.3mm x 0.3mm square.

To prepare this vector diagram for minimum-cost publishing, I then converted the drawing to Tiff 5.0 bitmap format at 300 dpi (in which the decimal point measures 4 x 4 pixels), and then scaled the bitmap to the '77% of original' size at which it is meant to be printed in *Nuts & Volts* (at which scale the point size reduces to 3 x 3 pixels). The complete bitmap was then printed out on high quality paper using a Laserjet printer and mailed off to *Nuts & Volts*.

On receipt of my artwork, *Nuts & Volts* scanned my bitmap into the magazine's printer, which then transferred the diagram to the printed page, where the decimal point probably measures 2 x 2 pixels, i.e., its size has fallen from 16 pixels to 4 pixels in the production process.

Thus, this minimum-cost artwork production process results in severe loss of the decimal point's definition. This problem can be reduced, at a much increased cost, by supplying the publisher with a disk copy of the full-scale Tiff 5.0 bitmap, which can then be fed — at an appropriate scale — directly into the publisher's printer, but even this process results in a final decimal point size of no more than 9 pixels at 77% scale.

The important thing to note from the above is that decimal points often become severely degraded during the printing

process and, in their 1975 report, the BSI recommended that, for component/parameter value notation purposes, the decimal point should no longer be used and should be replaced by the basic component/parameter multiplier symbol (such as V, k, n,  $\mu$ , etc.) applicable to that value. Thus, in this system, values such as 4.7V, 4.7k $\Omega$ , and 4700pF (= 0.0047 $\mu$ F or 4.7nF) become 4V7, 4k7, and 4n7.

## AN OVERVIEW

There are four major differences between the International and US Customary notation systems, and two of these are illustrated in *Figure 9*, which shows the multiplier symbols that are used in the International system; compare this diagram with that of *Figure 8*, and note that the International system uses the symbol R to indicate basic resistance units, and uses the symbol n to indicate 'thousandths of a  $\mu$ F' capacitance units.

Of the remaining two differences, one is that — in circuit diagrams — the International system does not use basic component 'type' symbols (such as  $\Omega$ , F, or L) as component postscript notations, and the other is that the International system used the component's multiplier symbol in place of a decimal point in the actual component-value notation.

## SPECIAL NOTES

Note that, although the BSI 'International' style of parameter-value notation was originally developed in the days when text was typewritten and circuit diagrams were hand-drawn, it still has great validity today, when text is generated on a wordprocessor and drawings are generated via a CAD package.

The US Customary notation '0.0047 $\mu$ F,' for example, looks clumsy, takes up lots of valuable text or drawing space, and takes 10 keystrokes to produce; the equivalent '4n7' International notation is, on the other hand, crystal clear, takes up a minimum of space, and takes only three key-

strokes to produce.

Most real-life International component notation codes consist of two or more digits plus one symbolic 'multiplier' notation; thus, in *Figure 5*, resistance values of 10k and 10R and capacitance values of 100n, 10 $\mu$ , and 220 $\mu$  are used. When below-unity values such as 0.1 or 0.5 $\mu$ H occur, they are notated 0R1 or 0 $\mu$ 5 in the International system. Note that the use of a two-digit code loosely implies a two-digit degree of component precision; thus, if an 8 $\Omega$  resistor is to be used in a semi-precision application, its value should be notated 8R0, but if it is only a very approximate value (such as a speaker impedance value), it can legitimately be simply notated as 8R.

The most important real-life tests regarding 'International' versus 'US Customary' component value notation systems are those relating to ease-of-use and final appearance on the printed page. You can only pass a fair comment on the first of these tests by making a genuine effort to get used to the International system, which is used by most engineers and electronics hobbyists throughout Europe and much of the rest of the world.

Regarding the second test, you can make a quick decision on this with the help of *Figure 10*, which shows a matching selection of International and US Customary component notations reproduced in extra-high-quality at 100% scale (full size), at 77% scale (the normal Nuts & Volts size), at 66% scale (the normal paperback handbook size), and at 50% scale (the normal small pocketbook size). Note the way in which the decimal points degrade in the smaller-scale US Customary notations.

I think the International notation system is the best of the two, and to help novice readers get used to it, future articles will, when appropriate, carry a small 'Beginner's Guide' box, giving a concise explanation of the International notation system (see *Figure 11*). If lots of readers continue to have problems, I will revert to the US Customary notation system in a future series. NV

### Beginner's Guide to Component Notations

In this article, the values of resistors and capacitors, etc., are notated in International — rather than US Customary — style.

In resistance notation, the symbol R represents units of resistance, k represents thousands of units, and M represents millions of units. Thus, 10R = 10 $\Omega$ , 47k = 47k $\Omega$ , 47M = 47M $\Omega$ .

In capacitance notation, the symbols  $\mu$ , n (= 1000pF), and p are used as basic multiplier units. Thus, 47 $\mu$  = 47 $\mu$ F, 47n = 0.047 $\mu$ F, 10n = 0.01 $\mu$ F, and 47p = 47pF.

In the International notation system, decimal points are not used in notations and are replaced by the multiplier symbol (such as V, k, n,  $\mu$ , etc.) applicable to the individual component value. Thus, 4V7 = 4.7V, 4k7 = 4.7k $\Omega$ , 4n7 = 4.7nF, and 1n0 = 1.0n.

Figure 11. 'Beginner's Guide' box, giving a concise explanation of the International notation system.

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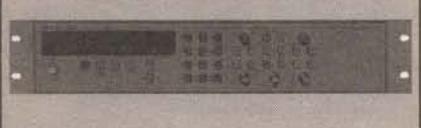
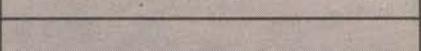
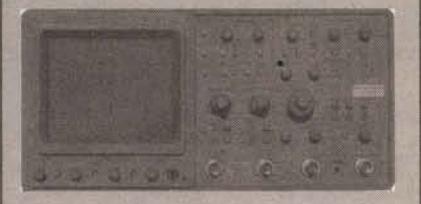
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# RESOURCE BIN

number eighty three

## Fun with some neat stuff.

Our usual reminder here that the *Resource Bin* is now a two-way column. You can get tech help, consultant referrals, and off-the-wall networking on nearly any electronic, *tinaja questing*, personal publishing, money machine, or computer topic by calling me at (520) 428-4073 weekdays 8-5 Mountain Standard Time.

There's sure a lot of neat electronics and related high-tech toys which are coming out lately. Both new and as surplus bargains. So, I guess we are overdue for a review of a lot of odds and ends that you just might decide are interesting or useful ...

### Build Your Own Microprocessor!

Programmable gate arrays are now large enough and cheap enough that you can use them to create your own microprocessor, ending up having the power of, say, a 6502 or a Z-80.

Besides being a superb teaching or learning experience, your own micro lets you run your things your ways. Using any mix of conventional, RISC, or DSP tricks you select. There's also those sole source and security factors. Others are not likely to guess exactly what you've got inside the box.

Typical FPGAs of interest include the *Xilinx XC4005L*. A new firm going by the name of *Space-Time Productions* now has new hardware and software support systems which literally can let you design your own micro.

These are also distributed by *Ultra Technology* whose lines do include a variety of Forth-based products.

### PSD Optical Rangefinding

There is great interest these days in sensing distances. Traditional optical rangefinders using *parallax* methods all had a serious flaw. In that moving parts were always involved. But it is possible to "inside out" the *parallax* method and make an all solid-state optical rangefinder. The trick

is to use a special beastie called an infrared *Position Sensitive Detector*.

A pair of side-by-side plain old light sensors can even be used. You illuminate what you are measuring by using a laser or an infrared LED. You then arrange your optics so that your image moves across the sensor pair as the distance changes. The ratio of left to right output is trig related to your distance to the target.

**NEXT MONTH:**  
Don looks at some possibilities in the medical electronics area.

There is one insider trick: To make the range signals independent of color and brightness, you'll *normalize* them by calculating  $(A-B)/(A+B)$ . Leaving you with a *differential* output which is proportional to range only. Yeah, that division gets tricky to do analog, but is not that big a deal digitally.

Position sensitive detectors are sold by *Sharp*, *Hamamatsu*, and *Ricoh*. The *Sharp GP2D02* is a good starting point. This chip is both low-cost and micro-friendly. Several of the intended apps include camera autofocusing, car "too close" alarms in garages, and even for use in restroom hand dryers. More details and bunches of further optical rangefinding resources appear in [www.tinaja.com/glib/muse131.pdf](http://www.tinaja.com/glib/muse131.pdf). More theory about optical and PSD rangefinding in general can be found in various SPIE publications.

### Find That \$#@%# Cat!

The *Catfinder* is an interesting new take on mid-distance remote controls. There is a small handheld transmitter and up to four light weight remotes. You place one on your cat's collar to keep tabs on tabby. Press the button and the cat meows.

Well, beeps actually.

Another intended use is for people who always lose things. You attach a receiver to, say, your

VCR remote or your pager or whatever. When it gets inevitably misplaced, you find your *Catfinder* and then use it to find the remote. The claimed range is 50 to 80 feet, or the better part of half an acre. My own tests showed useful ranges, but were unable to reach their specified distances.

Cost is \$29.00 for a transmitter and one remote. And \$15.00 for extra remotes.

Your remotes get programmed to a selected channel by transmitting that channel while you install its coin cell battery. Programming is verified by a distinct double beep. The reasonably waterproof remotes are also optionally offered as contact closures rather than beepers. Leading to all sorts of remote controls.

### Luminance Probes

When you measure light, you may want to sense *brightness*, finding out exactly how much light you have. But other measurement times, you might be more interested in how bright the light *appears* to a human observer. In this case, you'll be more interested in measuring *luminance*.

These two can be wildly different, because the human eye varies in its response to different colors. Your eye sees green strongest, red moderately, but blue only rather weakly.

Typical silicon photocells are very strong in the infrared but wimpy in the blue. To measure luminance, you have to carefully collect the light from the precise area you want to measure. Then you'll have to carefully filter the light to exactly match the response of the photodetector. A calibration curve is a must. Finally, you'll measure the amplitude transformed light and then convert its value to digits.

Luminance measurement is used in everything from architectural lighting to color video monitor balancing to getting colors to print out properly as grays. Your classic luminance probe has been that pricey *Tektronix J6523*. These have recently become available surplus in "almost new" condition at sane prices. These are narrow beam devices that include viewfinding and focusing. They work everywhere from 18 inches to infinity as is. By adding standard photo close-up lenses, tiny or nearby dots can be resolved.

They are intended to work with the old *Tek J-16* digital photometer, but should be fairly easy to interface into nearly any DVM lashup or PC-based data acquisition system.

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### Class D Amplifiers

There's been many decades of false starts, but it finally looks like Class D amplifiers are here to stay. A Class D amplifier is basically a pulse width modulator that drives a high-power switch. Your switch is followed by a potent low-pass filter to recover your PPM audio. Advantages of class D are quite low standby current, ultra high efficiency, and the ability to use low voltages. Laptop computer stereo is an obvious new application.

# RESOURCE BIN

## SOURCES FOR UNUSUAL NEW CHIPS AND DEVICES

Analox Devices PO Box 9106 Norwood MA 02062 (617) 329-4700	Hewlett-Packard PO Box 10301 Palo Alto CA 94303 (415) 857-1501	Medianix Semi 100 View St Ste 101 Mountain View CA 94041 (415) 960-7081	Ricoh 3001 Orchard Parkway San Jose CA 95134 (800) 957-3436	Tektronix PO Box 500 Beaverton OR 97077 (800) 835-9433
Apex Microtechnology 5980 N Shannon Rd Tucson AZ 85741 (520) 690-8600	Kepro Circuit Systems 630 Axminster Dr Fenton MO 63026 (800) 325-3878	Micro Linear 2092 Concourse Dr San Jose CA 95131 (408) 433-5200	Sharp Sharp Plaza Mahwah NJ 07430 (201) 529-8757	Texas Instruments PO Box 655303 Dallas TX 75265 (800) 336-5236
Artemco PO Box 429 Ossining NY 10562 (914) 762-0685	Lindberg 304 Hart St Watertown WI 53094 (800) 873-4468	MX-Com Inc 4800 Bethania Station Rd Winston-Salem NC 27105 (800) 638-5577	Space-Time Productions 219 N Vale Ave Rockford IL 61107 msimon@tefbbs.com	Tripath Technology 3900 Freedom Circle #200 Santa Clara CA 95054 (408) 567-3000
Hamamatsu 360 Foothill Rd Bridgewater NJ 08807 (201) 231-0960	Linfinity Micro 11861 Western Ave Garden Grove CA 92841 (800) LMI-7011	National Semiconductor 2900 Semiconductor Rd Santa Clara CA 95052 (800) 272-9959	SPIE PO Box 10 Bellingham WA 98227 (206) 676-3290	Ultra Technology 2512 10th Street Berkeley CA 94710 (510) 838-2149
Harris Semiconductor Box 883 Melbourne FL 32902 (407) 724-7000	Maxim 120 San Gabriel Dr Sunnyvale CA 94086 (800) 998-8800	Qualcomm/VLSI 10555 Sorrento Valley Rd San Diego CA 92121 (619) 597-5005	Synergetics Box 809 Thatcher AZ 85552 (520) 428-4073	Xilinx 2100 Logic Dr San Jose CA 95124 (800) 244-7778

The Texas Instruments TPA005D02 is a good starting point. This \$3.48 chip provides two watts output from a five-volt supply with under half a percent distortion. Other sources are Harris, Apex, Linfinity, and Tripath.

For a historical perspective on Class D, see my *Electronics World* story for February of 1966. A current listing of Class D amplifier resources appears in my MUSE128.PDF.

### Load Banks

A load bank is simply a giant toaster. Several loaves at a time, even. These get used for resistive (or sometimes reactive) loads to test generators or windmills. And for industrial process heat. Or in student power labs. Or for alternate energy research.

Load banks come in several sizes. Um, it seems I picked up one that was a tad larger than I expected. Driving home why it really is a good idea to look at mil surplus before you bid on it. At

any rate, this one is rated at 60 kilowatts and handles DC, normal AC, and three phase AC. This dude is available at three cents on the dollar. Terms like "sturdy" and "adequate" come to mind. Yes, it has wheels. Sort of. FOB Thatcher. Truck or trailer available. Lots more on load banks at [www.tinaja.com/bargte01.html](http://www.tinaja.com/bargte01.html).

### Whenever the Chips Are Down

There are great heaping bunches of new integrated circuits coming down the pike. Here's a few candidates that I find rather interesting ...

**Analog Devices ADXL05** — A member of their new nanotech accelerometer family, useful for everything from measuring the earth's magnetic field to robot nav to air bags to premium microphones. Prices on these have finally dropped to reasonable. Free samples are sometimes offered.

**Medianix MED25101** —

Digital Karaoke Audio Processor. Huh? Apparently it strips vocals from existing recordings so you can sing along with them. This is really a 16-bit digital signal processor in drag. Includes a seven band graphic equalizer and soundfield simulation.

**Maxim MAX4173** — One of their high side current sensors. Used to monitor battery or circuit current values and directions. Some do provide internal sensing resistors; others are externally controllable. The high side connection preserves system grounds.

**Micro Linear ML4421** — It's a variable speed AC induction motor controller. The problem with speed control on a plain old AC motor is that you have to hold both amplitude and frequency in step with each other to keep the mag flux in bounds. Feedback sensing is also tricky. This chip seems to solve both problems quite well.

**Analog Devices AD9830** — This digital sinewave generator is also known as a DDS direct digital

synthesizer. You'll input a 16-bit digital word and get an analog sinewave back whose frequency is exactly controllable from near zero to around a third of its 50-MHz clock frequency. Uses the phase addition method where a selected value gets added to the ongoing result and sent to a sine lookup table.

### Texas Instruments TSL235

— A single chip light-to-frequency converter has a silicon photodiode and a current to frequency converter inside a single low-cost chip. Useful for measuring light intensity. Response is strongest in the red and infrared.

**MX-COM MX805A** — Unique Subaudio Signalling Processor lets you combine voice with very low-frequency digital commands. Based on CTCSS squelch tones. This little known outfit has all kinds of interesting and oddball chips for voice communication. Everything from cordless telephone scramblers to tone controllers.

**National LM1971** — National, of course, has all sorts of unique low-cost and high-performance audio devices. This one is a digital audio attenuator, otherwise known as an electronic volume control. It works directly in decibels, and gives a 62 dB control range over a 115 dB dynamic range. Mute is also available.

**Analog Devices SSM2163** — This new chip in their ongoing *Solid State Music* line is a complete high-performance audio mixer. The eight input channels can be sent in any combination to a pair of stereo outputs. Provides 63 dB attenuation in one dB steps. For multimedia, hi-fi, broadcast, paging, or musical instruments.

**Qualcomm Q2220** — A second direct digital synthesizer for communication and audio uses. Qualcomm seems the leader in advanced digital radio and communications chips. They're also big in trellis encoders and similar low bit error rate devices.

More info on these can be found at [www.questlink.com](http://www.questlink.com) or else by viewing their respective web sites.

### Some Other Toys

Here is some other stuff I've been recently playing with. Although once outrageously expensive, much of this is newly available as reasonable cost military surplus. Most of these have all sorts of "take it apart and make something new out of it" potential ...

**Plotters** — The older Hewlett-Packard pen plotters were once ridiculously expensive in larger

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sizes. These days, most people who can afford them do prefer the newer, faster, and vastly more flexible inkjet systems. But these old models still work just fine if you are on a low budget. Even in E-size, they are sometimes bargain priced and probably can be converted into such things as vinyl sign cutters or silkscreen mask makers as well.

**Industrial Furnaces** — Insulated boxes from *Lindberg* or *Aremco* easily hit temperatures of a thousand degrees or more and are now available at sane prices. Besides obvious arts and crafts uses, what can you do with one?

**Space Shuttle Receivers** — Data boxes which directly can receive 2287.5 MHz video are rather specialized, but these include a bandpass filter, attenuator, fancy receiver, even a quality power supply. There is all sorts of satellite monitoring potential here.

**Telemetry Downlinks** — Also known as Artery receivers, these unusual gray boxes offer lots of fancy fiber optic O combined with some expensive-looking small gold-plated VHF radio modules. Plus an easily modified 8035 computer and display.

**Sick Optics** — Most precision optics are extremely expensive. But sometimes you can find chipped or cracked items that work just fine for school demos or home experiments. For instance, badly mauled corner reflectors could often be masked or "stopped down" to create smaller and cleaner cubes. A retroreflector returns a light beam in the exact direction it came from.

**Inclinometers** — These sensors always know which way is up. Also known as *electronic levels*, the fancy rugged devices get installed on construction equipment for levelling. Some use the differential capacitance of a sloshing liquid in its butterfly-shaped

sensor. The better ones are servo-driven null seekers. Lots of possibilities here.

**Plate Thru Labs** — Yes, it is possible to do your own double sided plate thru printed circuit boards. No, these are neither cheap or simple. *Kepro* is the leading source. These can sometimes be found as electronic surplus.

**Tail Twisters** — It turns out the HVAC air conditioning folks have long used power servos. Honeywell's Modutrol is one example. These are intended for damper controls, but are useful to open or close valves or similar apps. Typically moving 90 degrees in half a minute with up to 35 inch pounds of torque. This is the same as applying 17.5 pounds of twist to a three inch diameter valve handle. More on Modutrols in MUSE130.PDF.

**Mystery Beer Coolers** — Not sure what these are, but the feds got conned into paying \$21,000.00 for the pair of them. They called them "ion gauges." Maybe so, maybe not. Try to picture a liquid hydrogen Dewyer around 18 inches in diameter and two feet high. A special probe reaches inside via an expensive looking vacuum fitting. There's some small electronics externally attached. EG&G Ortec is the brand. Definitely for sale cheap. You can use it for superconductivity demos or low-noise amplifier experiments. For more details, contact [casholzen@zianet.com](mailto:casholzen@zianet.com).

**Huge Light Bulbs** — Airport beacons at one time needed large and impressive 1200-watt incandescent lamps. These are now cheaply available and make superb test loads, process heaters, or high intensity lights. These also seem just bizarre enough to make a rather nice "monode" addition to an antique vacuum tube collection

**Extension Phone Lockouts** — These low-cost 2960 modules from the *Northern Telecom* folks

include a pair of 17-volt bilateral switching diodes. One use is to stop a picked up extension phone from blasting an ongoing modem or fax. Full schematics and more device details can be found in MUSE96.PDF and MUSE112.PDF.

**Mechanical Timers** — Stock "washing machine" timers consist of a small AC motor and scads of fairly heavy duty cam-driven contacts. They are easily converted into such things as hot tub, farm, or irrigation controllers. It's a real challenge to discover what you *really* can do with these beasties. New ones are readily available surplus or try your local dump.

## Two Contests

Let us have two different contests this month. First, the Catfinder folks have agreed to a special contest only for readers of my columns. Just tell them something new or unusual that you'd like to do with one or more catfinders. They'll award a dozen or more free evaluation units to what they feel are the most interesting.

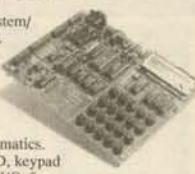
Send all of your entries on this one *directly* to the Catfinder address in the sidebar, or E-Mail [jgcurtis@inreach.com](mailto:jgcurtis@inreach.com). Getting back to the usual stuff, just tell me about any fresh new tech toy you've found to play with. One that I haven't heard of before. There will be a dozen or more of my *Incredible Secret Money Machine III* books going to the better entries. Plus an all expense paid *tinaja* quest for two (FOB Thatcher, AZ going to the very best of all).

Send your written and snail-mailed entries on this second contest directly to me here at *Synergetics*. Please be sure to keep these two contests separate.

Let's hear from you. NV

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**M**icrocomputer pioneer and guru **Don Lancaster** is the author of 35 books and countless tech articles. Don maintains his no-charge US tech helpline found at (520) 428-4073, besides offering all of his own books, reprints, and consulting services. Don is the webmaster of his Guru's Lair found at <http://www.tinaja.com>.

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27C512-25	2.99	2.84	2.56
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# Newsbytes

## COMPLIANCE AND INFORMATION ACTION

*Ship radio inspections to be privatized.*

In compliance with the requirements of the Telecommunications Act of 1996, the Commission has amended its rules to permit it to use FCC-licensed technicians in private sector organizations to inspect all US ships required to be inspected for compliance with the Communications Act of the International Convention for the Safety of Life at Sea.

Commission inspectors currently conduct inspections of a ship's required radio equipment for compliance with the Communications Act or the Safety Convention.

The FCC inspects approximately 1210 vessels each year. To be in compliance with the current rules — that require that all inspections be conducted by the Commission — the FCC has had to hire part-time ship inspectors in remote areas such as Guam and has traveled great distances to inspect radio stations on US ships.

The Commission estimates that total annual personnel required to inspect these ships is 15.5 full-time employees and travel costs to be \$50,000.00 a year. The new rules will relieve the FCC of these manpower and financial burdens, while permitting vessels the more convenient and cost-effective alternative of using FCC-licensed technicians from the private sector for inspections.

The new rules incorporate requirements suggested by the United States Coast Guard to ensure that maritime safety is not compromised. The new rules result in the following benefits:

• Privatization will increase the number of experienced entities available to inspect the radio stations of ships.

• Privatization will permit ship owners and operators to arrange for inspections at any time or place.

• Privatization should not adversely affect safety. The rules incorporate changes suggested by commenters that will require the use of a standard inspection check list with the FCC maintaining oversight of the inspection process as suggested by the US Coast Guard.

• Privatization will decrease administrative burdens on the Commission by shifting the responsibility to arrange ship inspections from Commission to ship owners or operators.



## MICROTECH ANNOUNCES USB-TO-SCSI CONVERTER

*Low-cost connectivity solution brings flexibility to iMac owners.*

Microtech International will now manufacture and ship a converter cable that allows SCSI storage devices to be connected to a standard USB port. The Microtech Xpress USB is a USB-to-SCSI converter which targets the hundreds of thousands of new iMac owners who may own older SCSI peripherals, such as hard drives, SyQuest, CD-ROM, or Iomega Zip and Jaz cartridge drives.

With an MSRP of just \$79.00, the USB-to-SCSI converter offers an affordable solution, filling a void created by the connectivity limitations of the iMac.

The converter is designed as a cable with a standard USB con-

ector on one end, and a male SCSI DB25 connector at the other. The SCSI connector is attached to the external drive and the hot-swappable USB connector is plugged in to the CPU or hub. The connector supports up to seven devices in true plug-and-play fashion, recognizing devices on the fly without requiring users to restart the computer.

The Xpress USB is fully compliant with the USB spec version 1.0, and delivers a maximum data throughput rate of 1.2MB/sec.

The first release of the software driver for the connector will support storage devices including Winchester drives and all removable media solutions. Microtech also promises an aggressive development schedule for driver updates and expects to support scanners and other third-party devices in upcoming revisions. All driver upgrades will be free-of-charge and available for download from the Microtech website.

Specific questions regarding compatibility and product support can be directed to Microtech Technical Support at 1-800-666-9689, or via E-Mail at nagy@microtechint.com.

Microtech expects to be shipping in volume on January 4, 1999, in time for MacWorld San Francisco. Units will be available through standard distribution channels, including Ingram Micro and Pinacor.

Information on all Microtech products is available at: <http://www.microtechint.com>.



## TELEVISION COMMERCIALS FOR THE INTERNET

**C**OMMERCIAL TV.COM now has available INTER-MMERICALS on the Internet. This is a new form of television commercial geared for the Internet. Commercial TV.Com is an Internet company that deals with surveys of television commercials and intermercials on the Internet.

It is assumed the Internet will soon become the focal point of many households and

corporations. Currently, commercials are produced for the television industry, but many companies are shifting gears to ride the high profile commercials and the mass exposure at a cost-effective price that the Internet will offer.

Give Commercial TV.Com a call at 1-800-700-8749 if using intermercials as a mass marketing tool applies to your situation. **NV**

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# Build An AIR JOYSTICK

It occurred to me, as I looked out the cockpit of my P-51 Mustang, that my plane's controls were kind of sluggish. However, off in the distance, I could see the German ME-109s coming at me in attack formation. I tried to roll out but just couldn't make the turn. My controls just wouldn't respond.

They were all over me. I was hit and hit again. One by one, the enemy strafe my wings. Then, it was all over ... it was the stupid controller.

I was using a normal Sega controller and it was just not designed to simulate an aircraft joystick. The game was fine, but I needed a better way to simulate the controls of the plane.

There are joysticks out there, but they all suffer from the same problem: They use two hands. What I needed was a one-handed joystick. It should respond by tilting the grip, but be constrained by a base. What I needed was an air joystick.

I have designed and built an air joystick that works by using mercury switches for the directional controls. It will work with any Sega Genesis game machine, can be made from easily-obtained parts, and costs about \$15.00 to build.

Before we build our air joystick, we must understand how the Sega controller works. The normal controller has eight switches in it: four for direction and four for functions (A, B, C, START). These eight signals are transmitted back to the Sega over six wires in the controller's cable. The other three wires are used

for ground five volts and a control signal.

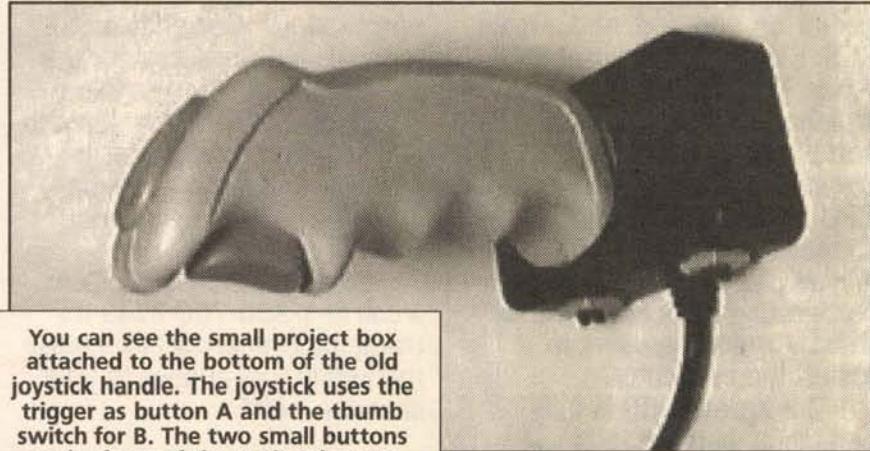
Since eight signals must be sent over six wires, the signals are arranged into two groups: A and B. The control signal sent from the Sega indicates which signals are requested.

To make this work, a chip is located inside the controller to route the correct signals requested by the Sega. The chip works like four relays working together. If the control signal is in a high (five volts) state, the RIGHT, LEFT, A, and START are sent. If the control is in a low (ground) state, the B and C are sent.

The UP and DOWN signals are not routed through the chip so they are present all the time. Some controllers have additional circuits to produce a machine gun effect with the fire buttons.

To make the air joystick work requires mercury switches (see Safety Note). These are similar to the mercury switches found in most home thermostats or silent light switches. As the switch is tilted, a tiny blob of mercury rolls from one end to the other inside a glass tube. At one end are two or three electrical contacts. When the mercury switch is tilted enough, the mercury rolls to the end with the contacts and completes the circuit. By positioning four mercury switches so each one represents one switch in the directional control, we can create a joystick.

I started building my joystick by obtaining an old, dead joystick. It doesn't matter what the joystick originally connected to since all we want is the grip. I found mine on a RadioShack clearance table, but any type will do. I was looking for a



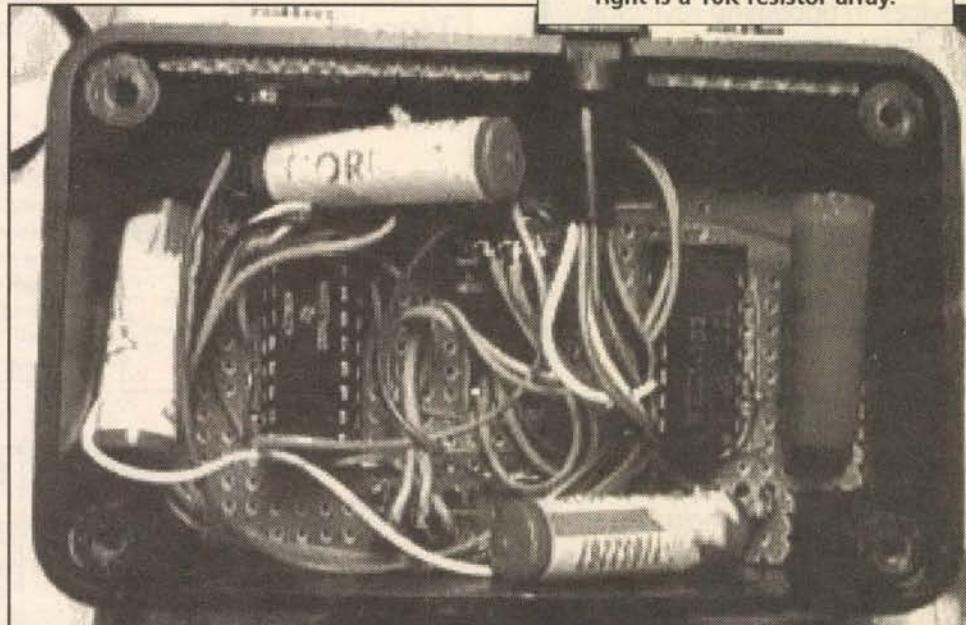
You can see the small project box attached to the bottom of the old joystick handle. The joystick uses the trigger as button A and the thumb switch for B. The two small buttons on the front of the project box are C and Start.

joystick that had at least two triggers; one for the index finger and one for the thumb. If you can find a joystick that has two or three thumb switches, that will work better.

Disassemble the joystick and discard everything but the grip. I thought about using the old joystick base to house the electronics, but the original base was oversized and too heavy for my use. Also there is a

to fit into the box. I used a utility knife and nibbling tool to trim the board to fit within the box. This might take several tries of trimming and test-fitting before the board fits correctly. When the board is finished,

This photo shows the electronics inside the air joystick. The small mercury switches (small tubular) are visible along the walls of the project box. They are tilted at approx. 30 degrees. The 74LS157 is the chip on the left while on the right is a 10K resistor array.



tendency to use it like a normal joystick.

When disassembling the joystick, keep the wires running to the triggers as long as possible. They will need to be about two to three inches long. If the wires are too short, open up the handle and extend the wires. The smallest project box RadioShack sells is perfect for our use.

Based on the joystick you started with, drill a hole in the center of the project box large enough for the trigger wires to pass through. This hole must be centered so the weight of the project box and electronics will be balanced. Attach the joystick handle to the project box with small screws. The box should be oriented so the narrow part of the box is forward and the wider part of the box is side-to-side (see photo). This will distribute the weight better and make it easier to use. Remember this joint should not flex, but must stand up if someone grabs it by the base.

Now we must trim the PC board

it should fit snugly at the bottom of the box. Drill a hole in the center of the PC board to accommodate the trigger wires as they pass through the box. The PC board will be the support and connection for all the remaining components.

Start by positioning the mercury switches so that each switch is at the edge of one main axis (up, down, right, left) of the PC board. It is best to position each switch so they all point in a clockwise or counter-clockwise fashion. This way each will repre-

## SAFETY NOTE

Mercury switches are made of liquid mercury encased in a glass capsule. Care must be taken to see they are handled properly. Mercury switches are safe as long as the glass remains unbroken. MERCURY IS A DANGEROUS SUBSTANCE AND SHOULD NOT BE HANDLED FOR ANY LENGTH OF TIME. If a mercury switch becomes damaged or breaks, contact local authorities about disposal. UNDER NO CIRCUMSTANCES dispose of mercury switches in a fire, as mercury vapor is very poisonous.



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the game Shove-it. The speed of the game was slow enough that my movements were easy to detect and I could see if the movement was correct. Games that require lots of fast movement will not work since your movements can't be tracked accurately.

The other way to test the joystick is to build a tester that will light an LED for each movement or button push. This tester can be as simple as a resistor and single LED or a device that will test all the functions of a controller at once. If you supply the joystick with ground, five volts, and a control input, a single LED can be used to see if the signal from a movement or button push is present on the correct pin.

If your joystick doesn't work perfectly at first, check for solder bridges and broken wires. Possibly the chip could be in the socket backwards. The angle of the mercury switches will affect how much they have to be rotated before a signal is returned. One mistake I made was to wire the UP and DOWN switches in reverse.

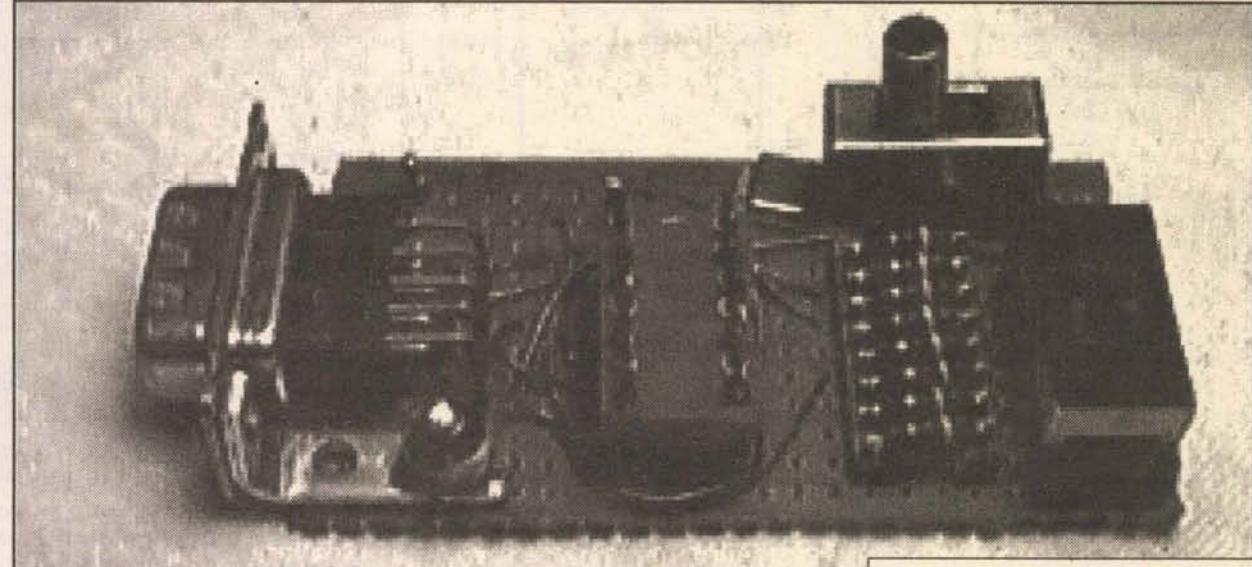
I was testing it on a aircraft flight game, so when I tilted forward, I normally expected the plane to descend and tilting back made the plane climb. This is correct for an airplane, but I found out that this is backwards for games. I re-wired the joystick. It was easier to think of it as a tank joystick where UP is forward and DOWN is reverse. By re-wiring, it makes it work like all other game controllers. It would be possible to add a DPDT slide switch to swap the UP and DOWN signals as required.

Now that you have your new air joystick, put on your VR helmet and fly that mission like it was meant to be flown, and kill a few bad guys for me ...

by MARK HANSLIP

Photos by George Stanley

# Build A SEGA CONTROLLER TESTER



*"Dad, the Sega controllers are messing up again. Can you fix them please?" Oh, the joys of being a parent. It amazes me how much abuse a video game control can take, and even more how much my son can dish out. I have replaced cords, contact pads, and a variety of other things.*

The problem with repairing game controllers is that you never quite know if the trouble is in the controller, the cable, or the machine itself. And once you have fixed the controller, you are not always quite sure if it's truly repaired. There is always the contact pads that shift and wires that get pinched.

The only way to test your repairs is to use the controller with a game that allows you to test all the

buttons and directions. This is almost impossible. And, very time-consuming.

To make my life simpler, I have designed a controller tester. It connects up to any Sega game controller and will display the output of all the buttons when pressed. This allows me to test the controller and find the problem, then test it later and see if my repairs have worked. The design is simple and easy to construct. I built mine in less than an hour with parts I had on hand.

A Sega controller uses a DB-9 female connector. Being a standard connector, this makes finding a matching connector very easy. The Sega was designed so that eight switches in the controller are attached to six wires in the cable. This means that sometimes two signals share one connector pin. To make this work, the Sega toggles pin 7 to enable the

This photo shows how simple the tester truly is. The controller being tested plugs into the connector on the left. The switch and LED display are on the right. In the middle of the board is a jumper block that was originally used to test the tester.

"A" or "B" set of signals. The tester takes this into account by using a slide switch to simulate the toggling of pin 7. A 555 could be used to continuously toggle the control line, but this would make the circuit more complicated and make the output harder to read. The signals for each connector pin are located in List 1.

The basic circuit has +5 volts, ground and the control signal are outputs to the controller under test. The six outputs returning from the controller are connected to LEDs for display. I decided to use a seven-segment display to keep the design

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Home Automation (X-10) - Connects between a TW523 and your serial port. Receive/transmit all X-10 commands with your home-brewed programs. Full collision detection with auto re-transmission. \$39

Caller ID - Decodes the caller ID data and sends it to your serial port in a pre-formatted ASCII character string. Example: \*1231 08:45 850-863-5723 Weeder, Terry <CR>. Keep a log of all incoming calls. Block out unwanted callers to your BBS or other modem applications. \$35

Touch-Tone Input - Decodes DTMF tones and sends them to your serial port. Keep a log of all outgoing calls. Use with the Caller ID kit for a complete in/out logging system. Send commands to the Home Automation and/or Digital I/O kits using a remote telephone. \$34

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## Phone Line Transponder

7 individual output pins are controlled with buttons 1-7 on your touch-tone phone. Automatically answers telephone and waits for commands. Monitor room noises with built in mic. "Dial-Out" pin instructs unit to pick up phone and dial user entered number(s). Password protected. \$49

## DTMF Decoder/Logger

Keep track of all numbers dialed or entered from any phone on your line. Decodes all touch-tones and displays them on a 16 character LCD. Holds the last 240 digits in non-volatile memory. Connect directly to radio receiver's speaker terminals for off-air decoding of repeater codes, or numbers dialed on a radio program. \$55

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HP 6269B 40VDC-50A POWER SUPPLY	\$800.00	TEK AM503 CURRENT PROBE AMPLIFIER	\$250.00
HP 6553A 40VDC-12.5A. POWER SUPPLY OPT.J01	\$1200.00	WAVETEK 145 20MHZ PULSE/FUNCTION GEN.	\$400.00
HP 6632A 20VDC-5A POWER SUPPLY	\$500.00	WAVETEK 182A 4MHZ FUNCTION GEN.	\$150.00
HP 6643A 45VDC-4.3A POWER SUPPLY OPT.J03	\$750.00	WAVETEK 955 7.5-12.4GHZ MICROSOURCE	\$1100.00

### List 1: CONTROLLER SIGNALS

PB-9	SIGNALS
1	UP (both a and b)
2	DOWN (both a and b)
3	LEFT (b) unused (a)
4	RIGHT (b) unused (a)
5	+5 volts
6	"A" (a) "B" (b)
7	CONTROL PIN A=GND B=+5
8	GROUND
9	"START" (a) "C" (b)

### List 2: PARTS LIST RADIOSHACK #

PC board	276-158
DB-9 male	276-1538
6 220 ohm 1/4Ww	271-1313
2.2K 1/4W	271-1325
Seven-segment display	276-075
Common anode (or 6 individual LEDs)	
SPST switch	275-645
14 pin IC socket	276-1998

### List 3: REPLACEMENT PARTS SOURCES

Parts to repair Sega controllers can be obtained from MCM Electronics, 1-800-543-4330 (Cable 83-385; Contact pads 83-1580).

### List 4: LINEOUT FOR SEVEN-SEGMENT DISPLAY

PIN	USE
1 TOP	UP
2 UPPER LEFT	LEFT
3 +5	
7 LOWER LEFT	A/B
10 LOWER RIGHT	C/START
11 MIDDLE	DOWN
13 UPPER RIGHT	RIGHT
14 +5	

small and simple. I used the upper part of the "\*" to display the directional controls. The top LED is "UP,"

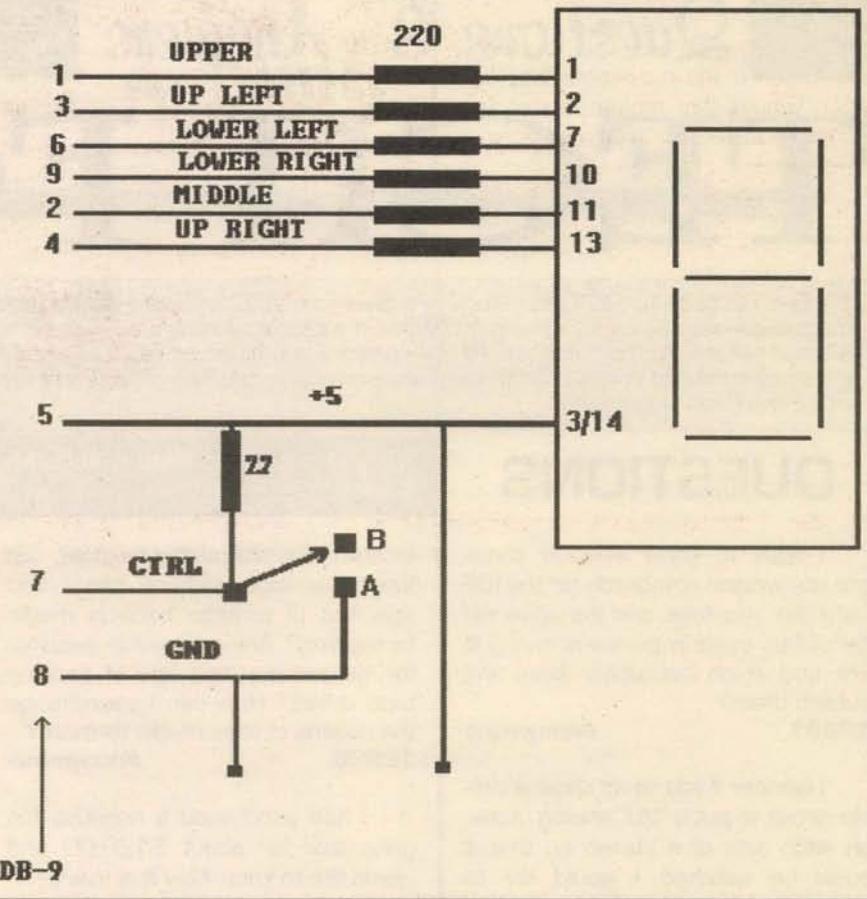
top and middle LED will still respond to the normal directional buttons. This is normal. Pressing the "A" and

the middle bar is "DOWN," the left LED is "LEFT," and the right LED is "RIGHT."

I used the lower left and right as the display for the A, B, C, and START buttons. An external power source of +5 volts will be needed to power the controller and tester. Sega controllers contain a 74157 IC so the operating voltage cannot vary too much from +5 volts. A possible alternative is to use a nine-volt battery and a five-volt regulator.

To test a controller, plug it into the connector on the tester. Set the switch to "B" (five volts) and start by pressing each of the direction buttons. With each press, the corresponding LED should light. Next, press "B" and "C." These should each light a lower leg of the display.

To test the "A" set, slide the switch to the "A" position. The upper right and left LED will light and stay on, but the



"START" buttons will each light one of the lower legs of the LED display. If any LEDs fail to light when the appropriate button is pressed, a problem has been found within the controller.

This tester will save you a

tremendous amount of time. It will help you to correctly replace contact pads, locate broken cables, and other problems with controllers.

It even helped me build and test a special joystick for my son, but that's another story ... NV

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This amazing device can also be used as a handy continuity tester. It is very unusual in that it does not use batteries, yet provides indications on a small LCD display. As the probe tip is brought near a line cord, which is plugged into 120VAC or DC, a special symbol is displayed on the LCD display (no need to touch the probe tip to a live wire as it can detect the presence of AC through insulation). Will also measure approximate AC or DC voltage level from 12V - 220V AC or DC and will display a digital approximation (12V, 36V, 55V, 110V, 220V) if probe tip is touched to a "hot" wire. Can also identify blown fuses, circuit breakers, faulty insulation, etc. Very handy brand new in retail blister package.

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Write in 54 on Reader Service Card.

Nuts & Volts Magazine/December 1998 41

## Questions & Answers

# TECH FORUM

This is a READER TO READER Column. All questions AND answers will be provided by *Nuts & Volts* readers and are intended to promote the exchange of ideas and provide assistance for solving problems of a technical nature. All questions submitted are subject to editing and will be published on a space available basis if deemed suitable to the publisher. All answers are submitted by readers and *NO GUARANTEES WHATSOEVER* are made by the publisher. The implementation of any answer printed in this column may require varying degrees of technical experience and should only be attempted by qualified individuals. Always use common sense and good judgement!

## QUESTIONS

I want to know whether there are any written standards for the IDE hard disk interface, and the universal serial bus used in personal computers, and which institutions keep and publish them?

**12981** **Anonymous**

I wonder if you could show a simple circuit to put a "VU" analog meter on each side of a stereo so that it could be watched. I would like to attach them between the stereo and the speakers, and be able to adjust the meters sensitivity, if possible.

**12982** **B. E. Holtermann**  
Bena, VA

On the Internet and in other documents, I see the use of the TCM3105 202 modem chip. It works well, but appears to be out of production. Is it second sourced or does someone have a big stash of them?

**12983** **Neal Collier**  
Pensacola, FL

I need the specs on GP1U52X IR receiver/demodulator, or at least the name of the manufacturer. I am trying to build an IR switch.

**12984** **Bhavesh Parikh**  
via Internet

I am looking for an inexpensive outbound call monitoring system, one that will keep a record of the numbers dialed from a given phone, along with the date and time of the call. I need to handle about 200 calls before any storage medium is overflowed.

RadioShack used to market a small unit that recorded the data on a roll of paper, but they do not offer it any longer. Inexpensive is the key here. While a stand-alone unit is preferable, a computer can be made available if needed. Kits or simply plans will also be considered.

**12985** **Steve Bepko**  
Baltimore, MD

I have a TEAC 700 computer back-up tape drive that works fine with a 3010 formatted tape. How can I low-level format a QIC Wide (as cartridge modified) or QIC 80 tape?

Using Arcada or Microsoft back-up software, the head of the tape is

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located, but the software does not format a tape. Where can I find specifics of strange back-up media formatting? Are programs available for general-purpose use of back-up tape drives? How can I interchange the dozens of tape media formats?

**12986** **Anonymous**

I had purchased a negative ion generator for about \$120.00 and would like to know how it is made.

I would like to make a more powerful one. It looks very simple, but the parts are encased in a hard plastic with no markings on the outside.

**12987** **Patrick McGuinn**  
via Internet

I need a simple countdown circuit to count from a preset value of 2-12 to zero. It needs to provide an output at zero. Levels are no problem. I can adapt to the voltages I need.

I have been out of this stuff for a long time. Last time I did this, I used a motor driving a disk with a wiper!

**12988** **Dave Schoepf**  
Marianna, FL

I was given a Genographics film recorder model# F.R. PSM 3 Rev.G. It included an ISA card. Does anyone know where I can get drivers for it?

**12989** **Richard Coppola**  
Bayside, NY

I have an enormous (24 lbs.) FUJITSU model M2312K 8" hard drive part# B03B-4595-B002A, date 1985-3. I am really curious about the specs on this piece of history—speed, interface type, capacity, original computer, etc.

**129810** **Richard Coppola**  
Bayside, NY

I have a number of exhibits that rely on NiCad rechargeable batteries. Consequently, each manufacturer prescribes a different preferred schedule for recharging the battery, which I have followed (recharge as little as possible vs. keep at maximum charge, charge no longer than seven hours vs. always keep charged).

Is there any generally preferred schedule, or should every battery be treated per its instructions?

**129811** **Thomas Ng**  
San Jose, CA

I recently acquired an RCA CCTV camera model TC101 and monitor model TC1112. The system worked fine until the monitor failed.

I am seeking the following information: 1. What type of adapter to buy or build so the camera can be used with a standard TV monitor (there is a sync conflict)? 2. A service manual or schematic of the original monitor.

**129812** **Joe Pitman**  
via Internet

A while back, I remember reading either an article or a reader's comment in *Nuts & Volts* about those stripes that are in the new money. Can anyone with the proper scanner "scan" you or your house to see how much money you have?

**129813** **Dave Mikesch**  
via Internet

I am looking for two schematics that are relatively simple, but currently beyond my ability to manufacture.

1. A circuit that would power a very loud sonalert-type device (regularly timed pulses versus a continuous tone) that I could mount in my model airplanes so I have an audible tracking aid when and if I lose another one.

2. A simple timer that would activate with one SPDT switch that would beep once at one minute from the time it was started, twice at two minutes, and so on up until about 20 minutes or so.

If someone could tell me where to find such a circuit, I can build it, I just can't design it.

**129814** **Tom**  
via Internet

I am trying to interface various sensors/transducers to the serial/parallel ports of my IBM-clone.

A major improvement would result if I could (temporarily) modify the system-boards 8253 timer IC, so as to generate interrupts every 0.1 milliseconds, instead of the standard 55 millisecond limit.

Can this be done at all? I know "C" fairly well, but when I tried output b[] to the 8253 (assuming the control register is at addresses 0x043 and the third counter is at 0x42),

## ANSWER INFO

- Include the question number that appears directly below the question you are responding to.
- Payment of \$25.00 will be sent if your answer is printed.
- In most cases, only one answer per question will be printed.
- Your name, city, state, and E-Mail address, (if submitted by E-Mail), will be printed in the magazine, unless you notify us otherwise with your submission.
- Due to space limitations, we can not reprint the original questions with the answer. The question number and the issue it appeared in are printed above the answer.
- Unanswered questions from a past issue may still be responded to.
- Comments regarding answers printed in this column may be printed in the Reader Feedback section if space allows.

## QUESTION INFO

### TO BE CONSIDERED FOR PUBLICATION

All questions should relate to one or more of the following:

1) Circuit Design 3) Problem Solving  
2) Electronic Theory 4) Other Similar Topics

### INFORMATION/RESTRICTIONS

- No questions will be accepted that offer equipment for sale or equipment wanted to buy.
- Selected questions will be printed one time on a space available basis.
- Questions may be subject to editing.

### HELPFUL HINTS

- Be brief but include all pertinent information. If no one knows what you're asking, you won't get any response (and we probably won't print it either).
- Write legibly (or type). If we can't read it, we'll throw it away.
- Include your Name, Address and Phone Number. Only your name will be published with the question, but we may need to contact you.

nothing happened. Any suggestions?

**129815** **Thomas Ng**  
San Jose, CA

Does anyone know how to build a code scanner for Mitsubishi cars? The scanners for other makers are available now.

**129816** **Yan Wu**  
Boston, MA

I have a couple of data loggers which record a 0-5V DC signal, at 20 samples per second. Unfortunately, the sensors I would like to use with

## TECH FORUM

these data loggers produce various outputs, (i.e., 0-50MV DC, 0-500MV DC and 0-1V DC).

I would like to construct or purchase ready made, what I believe would be called a linear DC amplifier with the inputs mentioned above and a 0-5V DC output that I could connect to my data logger. Can anyone help me?

129817 Peter Marsh via Internet

I have a piece of test equipment that has the GPIB interface. I want to use the GPIB to download data from that equipment to my PC. Can I accomplish this with a bi-directional parallel port, or do I have to shell out \$400.00+ for a GPIB board? I am capable of writing the driver myself, but if this were possible someone must have done it. Any input?

129818 Bill Eaton Hamilton, OH

I enjoy reading and building projects in the *Nuts and Volt* magazine. I especially like the articles involving the BASIC Stamp and general articles on using serial and parallel ports to control projects.

I have read articles in the past to change a SVGA monitor to a RGB, but I don't know if the reverse is also possible.

I have a digital 19" monitor model #VR 299-DA manufactured in June 1990. The monitor has three BNC connectors (RGB) on the back. Other information Hz: 50-60, W: 150, V: ~100-120, A: 2.2.

I was interested in hooking the monitor up to my computer SVGA output. Is this possible? What will it take?

129819 Matt Drotter via Internet

Apple II emulators for the IBM PC require that images of the Apple diskettes be stored on the PC. I would like to build a hardware/software interface that would allow me to create these images by directly reading an Apple floppy drive connected to a PC via the parallel port or expansion bus.

Does anyone have details on how this could be done? Are there any detailed hardware manuals available for the Apple drive that would help me develop my own interface?

129820 John Reynolds via Internet

I have an old drawing program called DR HALO. I used it for drawing circuits and such. I would like to convert these drawings I saved in DR HALO format (PIC), to the new standard of BMP, PCX, TIF. I have been hunting for a conversion program for five years now.

The program CSHOW ver 8.76a will recognize the PIC format, but I can only view the drawings.

Does anyone know of a conversion program for this type of format and where I could get it?

129821 Terry Baker St. Paul, MN

I have an OPTREX DMF-633 display that I would like to interface with. I would like to know if there are any circuit examples of using an EPSON SED1330 or SED1335 controller with this display.

129822 Anonymous

I have an old 486 motherboard that I would like to use in a robot. When the robot is running, I would like to unhook the keyboard and monitor. How can I bypass the keyboard and monitor? I have looked through the bios, and there is no way to turn it off.

129823 Brent Lamb Lubbock, TX

I read Karl Lunt's March and April '98 articles on hacking the GameBoy.

I tried looking on Jeff Frohwein's web page and his links, but I can't find something.

Do you know where I can get info on hacking the GameBoy Camera? I want to use it for very crude object recognition — with or without interfacing to the GameBoy.

Any schematics, pinouts, or code related to the GameBoy camera would be really helpful.

129824 Jim Awrach

## ANSWERS

### ANSWER TO #10985 - OCT. 1998

In response to Robert Ritchey's question on the jumper settings for his Magitronics Motherboard. He can contact the company by writing: **Magitronic Technology, Inc.**, 6585 Crescent Dr., Norcross, GA 30071; **1-800-4-LIUSKI**. They are the parent company to Magitronics.

They also have web sites which E-Mail inquiries can be made, as well as information and files on their products can be obtained.

I checked the site and the product Robert has, it is outdated and not supported on their web page. But they do state that if you contact them on older motherboards and give the information he gave in his question, they would fax or mail the information on the motherboard jumpers if they still have it available. Their web page is <http://www.magitronic.com> or <http://www.liuski.com>.

Wesley K. Miller  
Camp Hill, PA

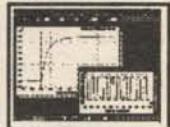
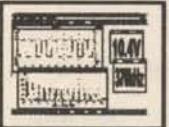
### ANSWER TO #10987 - OCT. 1998

The 8909-02A microprocessor reads the push buttons and signals from the remote control and programs the TV accordingly.

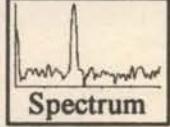
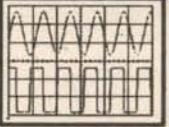
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This IC is found in Goldstar Chassis NC-91A and is available from: **Shine Electronics**, 11-22 45th Rd., Long Island City, NY 11121; **1-800-243-0000**.

This identical chassis family is used in the J.C. Penney model 2193 (685-2193; Catalog No. 855-9007) and the IC is available from: **Cititronix**, 1641 Dielman Rd., St. Louis, MO 63132-1597; or Panson Electronics, 1-80 & New Maple Ave., P.O. Box 2003, Pine Brook, NJ 07058; **1-800-846-2484**.

Before you call have the part designator from the PC Board (IC1 in both of the above chassis', but check yours to be sure) and the model number and serial number of your set. These microprocessors have internal ROM and the code is sometimes modified over the life of the product. The microprocessor from an earlier serial number might not work in a later one.

Expect to pay \$25-\$30 including shipping.

Bob Miller  
Trenton, NJ

### ANSWER TO #10988 - OCT. 1998

Yes, there is a memory expansion board available for the LaserJet HP II.

There are two types of memory expansion cards, 4 meg and 2 meg that you will have to populate with memory chips. (The 2 meg HP cards can be connected together to make

4 megs. Note: The maximum amount of memory that the HP II will recognize is only 4608K bytes.)

I have found lots of dead laser printers at my local electronics surplus stores, and have been buying them for parts machines.

Unfortunately, I don't have any memory boards left right now. But here are a few places that sell laser printer parts: **Laser Products Co.**, 1534 Burlington Ave., Kansas City, MO 64116; phone: **1-800-786-8897**, fax **816-471-1677**. **GOLD-SMITH GROUP**, Indianapolis, IN; phone: **1-800-989-7295**, fax **317-545-4883**; E-Mail: [recycle@quest.net](mailto:recycle@quest.net), website: [www.goldsmitgroup.com](http://www.goldsmitgroup.com)

Terry Baker  
St. Paul, MN

### ANSWER TO #11984 - NOV. 1998

There is no way to prevent duplication of your audio cassette tape, using an electronic gadget or otherwise. In fact, at this point in time, it's easy to dub analog audio cassette tapes, DAT (digital audio tapes), digital mini-discs, and even audio CDs, and also to copy from one format to another.

If your tape can be played back in a standard cassette player, then it's possible to patch the audio from the player into a second deck and make a dub of your original tape. Even if you record the tape at a non-standard speed, requiring the end user to

## TECH FORUM

### ANSWERS TO #11985 - NOV. 1998

The 3UP1 is a three-inch CRT with electrostatic deflection. There are two pairs of deflection plates, one for horizontal and one for vertical. The included schematic is for a simple deflection amplifier to drive the plates. You will need two such circuits, one for vertical plates and one for horizontal plates. I am presently using this circuit with a 3RP1 CRT, which has similar electrical characteristics.

The circuit is based on a classic differential amplifier. Q3 forces the sum of the currents through Q1 and Q2 to be constant at 3 milliamperes. The voltage difference between the Q1 and Q2 collectors (applied to the plates) is a function of the difference between the Q1/Q2 base voltages. One base gets the signal input (from the 0-5V DAC output in your case), while the other gets a DC voltage (about 2.5 volts) that positions the undeflected spot in the center of the CRT face. The signal input must be DC-referenced

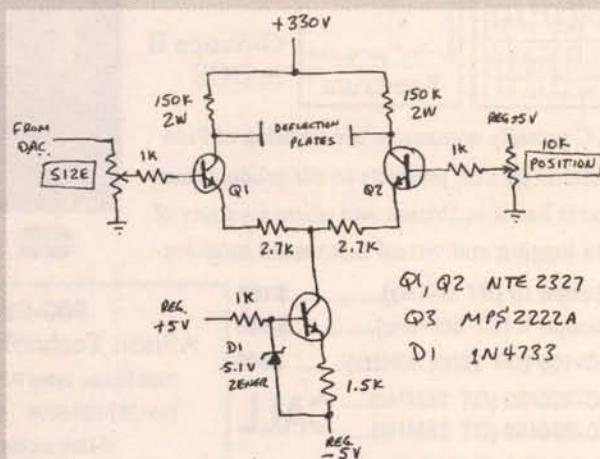
to circuit ground.

If the 3UP1 deflection plate capacitance is indeed 20 picofarads, the effective bandwidth of this amplifier/CRT combination should be at least 50 kHz. My guess is that actual capacitance is lower, so bandwidth will be greater.

For even more bandwidth, you could decrease the emitter/collector resistor values and increase the circuit current.

If you cannot obtain sufficient deflection range with this circuit, try increasing the +330 DC supply, making sure that Q1/Q2 have adequate VCC rating.

Joe Moell  
Fullerton, CA



obtain a non-standard player from you, the tape could be duplicated two ways: By connecting the audio output from the special player to the input of a standard recorder, or by playing it on a readily-available variable-speed player.

Consider this drastic — but unrealistic — solution: You load the original non-standard tape on the non-standard player, and weld the player into a steelplate box, with only the controls and speaker accessible, with explosives enclosed to prevent opening the box.

Now, your customer can play the tape, but can't get it out for duplication.

Even so, it would be possible to make a fairly good recording from the loudspeaker in your special play-

er, by using a high-quality microphone, and probably some audio filtering [to compensate for the frequency response of the player's speaker].

So, unless the audio quality needs to be exceptionally good [maybe very high-fidelity music, for example — but audio cassettes aren't capable of high audio quality], someone could make a usable duplicate.

Unauthorized copying is a sore point with the music industry. They lobbied to have circuitry put into DAT decks that prevented making multiple direct-digital copies of digital originals. [This process kept DAT decks off the US market for so long that it effectively killed the demand for them.]

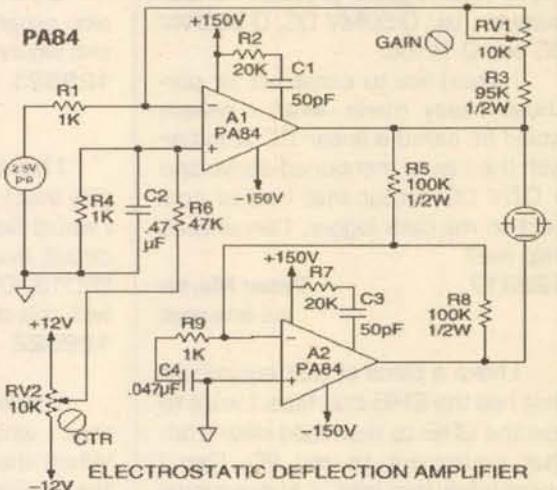
Even so, you can easily connect

### ANSWERS TO #11985 - NOV. 1998

Design of a high-voltage deflection drive amplifier with 3 MHz bandwidth is no trivial task. However, there is a device made by Apex Microtechnology that was actually designed for your application.

I am assuming that your CRT uses static deflection because of the low (20 pF) capacitance you quoted. The circuit in the schematic is taken directly from their application notes and uses two PA84 high-voltage power op amps in a bridge configuration. This allows you to use a ±150V power supply to get a ±300V output swing.

You could hook a bipolar DAC output directly into the input of the amplifier. A unipolar DAC would require



some OV level shifting. A free data book for Apex Microtechnology devices is available at 1-800-546-2739. If you have Internet access their URL is: <http://www.apexmicrotech.com>

Kevin Goodwin  
Oceanside, CA

### GW BASIC and QBASIC.

How can I make such a claim? By testing your QB version as follows:

First, I connected the COM1: serial ports of my host and remote computers with a null modem cable. Then I wrote, loaded, and ran the following multimeter surrogate program on my remote computer.

```
10 OPEN "COM1:1200,N,7,2,RS,
CS,DS,CD" FOR RANDOM AS #2
20 IN$ = INPUT$ (1, #2)
30 IF IN$ <> "D" THEN 20
40 PRINT IN$
50 PRINT #2, "-12.34 volt DC"
60 CLOSE #2
```

Next, I loaded and ran [on QBasic] your QB version on my host computer. The character D was displayed by my remote computer; the string -12.34 Volt DC was displayed by my host computer, thus verifying the fundamental integrity of both programs.

After I added line numbers to

Continued on page 64

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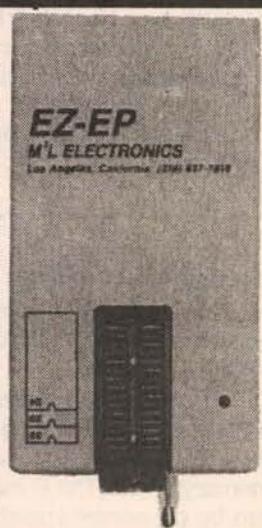
- Broad support for additional devices using adapters listed below.

#### Available Adapters

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EP-PIC12 (12C50x)	\$39.95
EP-PIC17 (17C4x)	\$49.95
EP-51 (8751,C51)	\$39.95
EP-11E (68HC11 E/A)	\$59.95
EP-11D (68HC711D3)	\$39.95
EP-16 (16bit EPROMs)	\$49.95
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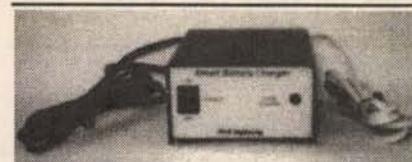
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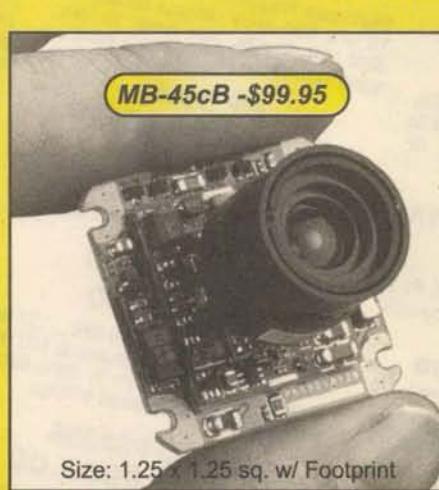


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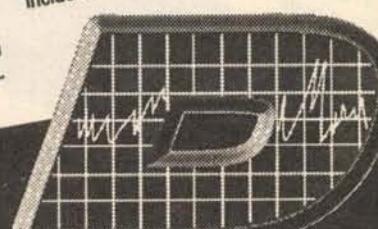
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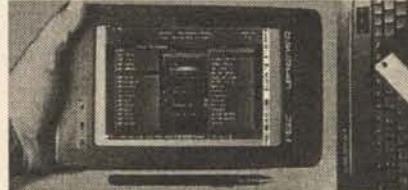
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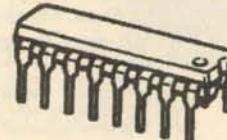
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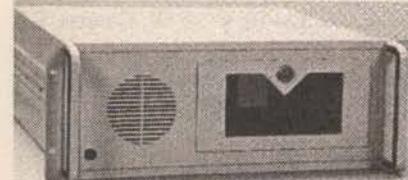


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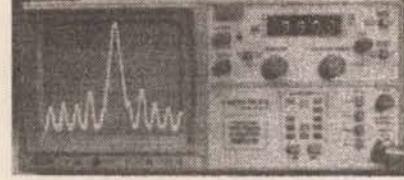
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FM-100, Professional FM Stereo Transmitter Kit.....\$299.95  
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### AM Band Radio Transmitter



Ramsey AM radio transmitters operate in the standard AM broadcast band and are easily set to any clear channel in your area. Our AM-25 'pro' version, fully synthesized transmitter features easy frequency setting DIP switches for stable, no-drift frequency control, while being jumper settable for higher power output where regulations allow. The entry-level AM-1 uses a tunable transmit oscillator and runs the maximum 100 milliwatts of power. No FCC license is required, expected range is up to 1/4 mile depending upon antenna and conditions. Transmitters accept standard line-level inputs from tape decks, CD players or mike mixers, and run on 12 volts DC. The Pro AM-25 comes complete with AC power adapter, matching case set and bottom loaded wire antenna. Our entry-level AM-1 has an available matching case and knob set for a finished, professional look.

AM-25, Professional AM Transmitter Kit.....\$129.95  
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Has built-in speaker or earphone connection, runs on standard 9 volt battery. Complete kit includes handsome case, rugged PVC handle assembly that 'breaks down' for easy transportation and shielded Faraday search coil. Easy one evening assembly. This nifty kit will literally pay for itself! That guy in the picture looks like he found something - what do you think it is - gold, silver, Rogaine, Viagra? You'll have fun with this!

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BNO-1, Binoculars and case.....\$24.95  
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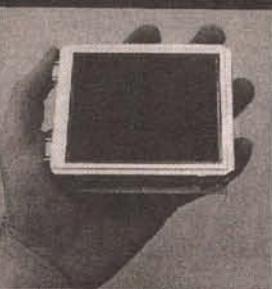
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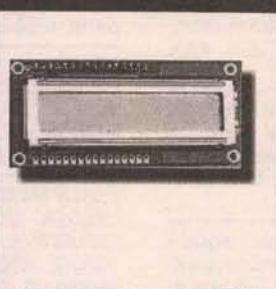
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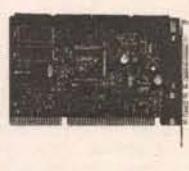
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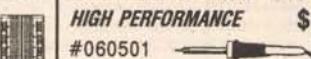


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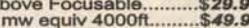
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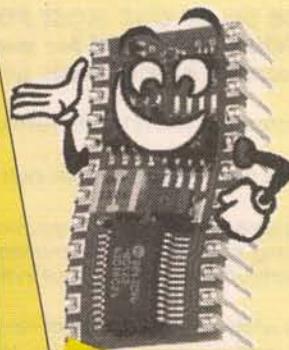
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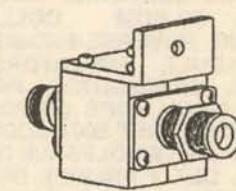
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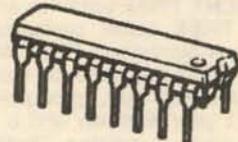
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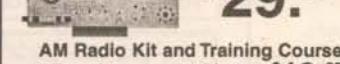


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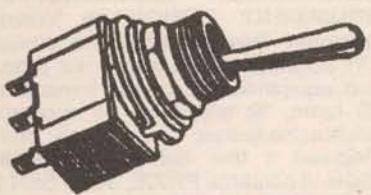
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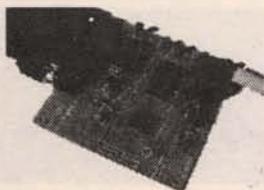


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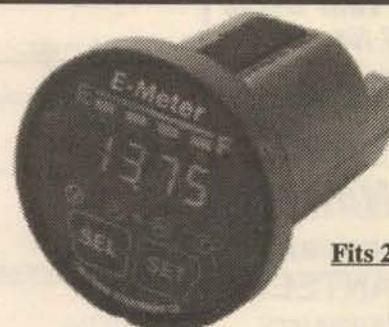
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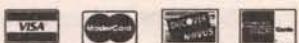
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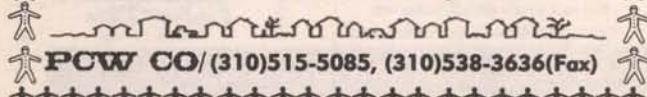
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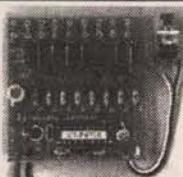
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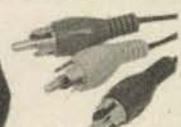
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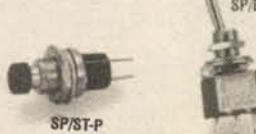
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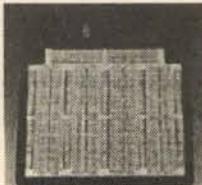
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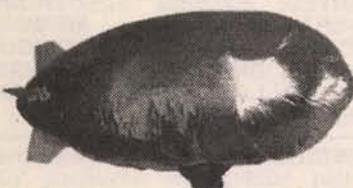
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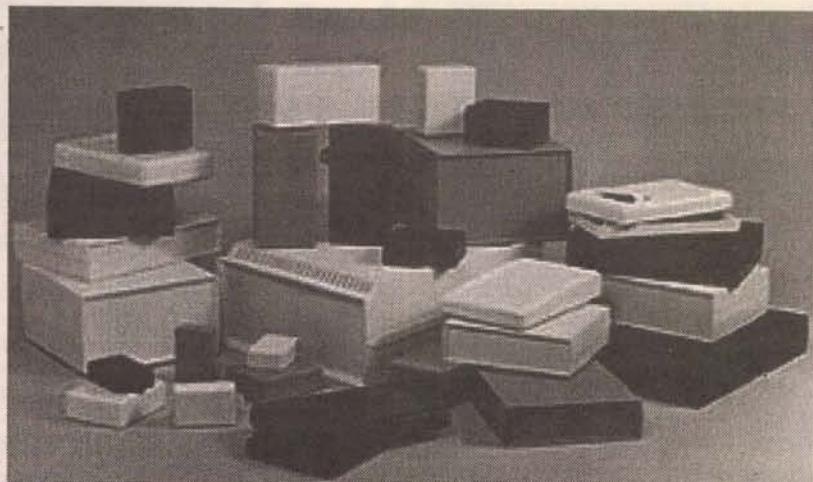
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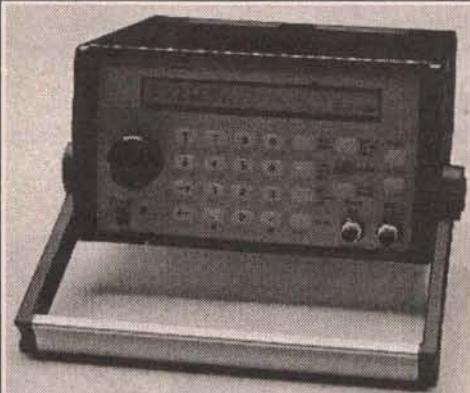


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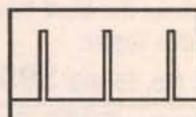
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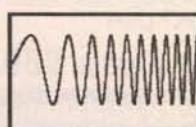


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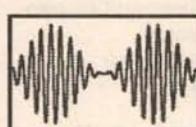


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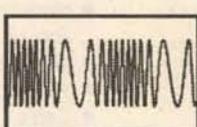
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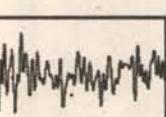
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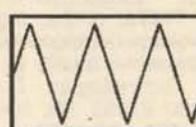
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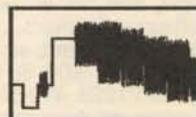
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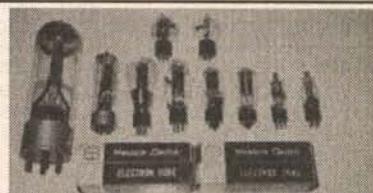
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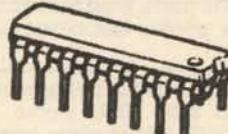
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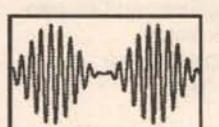
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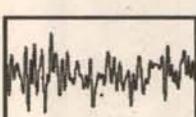
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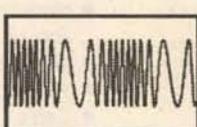
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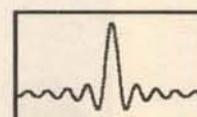
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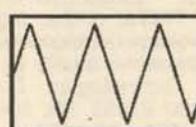
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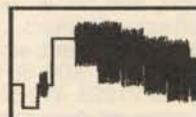
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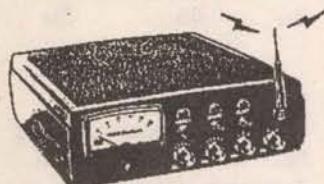
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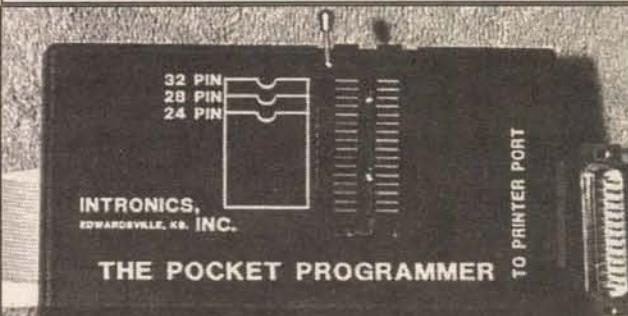
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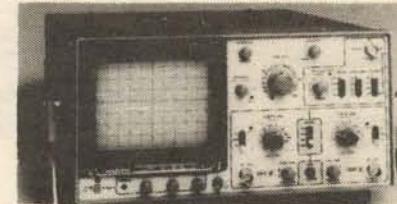
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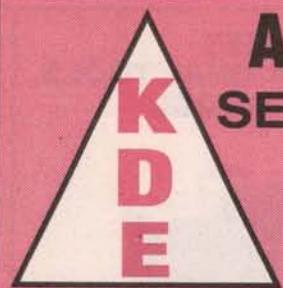
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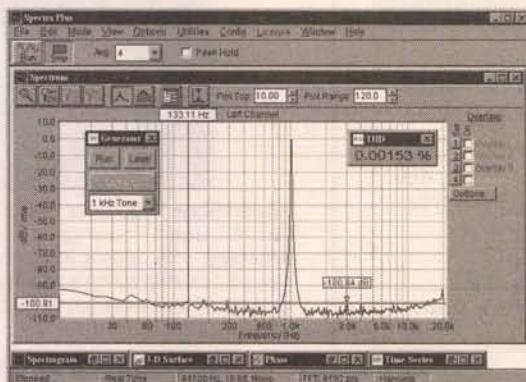
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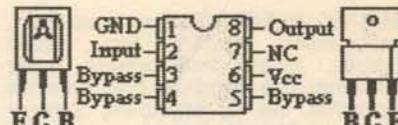
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## TECH FORUM

*Continued from page 44*

your QB version, I was able to run it on GW-BASIC 3.20, 3.22, and 3.23 (as well as on QBASIC) with exactly the same results. [If you run it on GWBASIC 1.00 or 2.02, you will need to remove the words FOR RANDOM from the OPEN COM statement (or you will get a syntax error.)

My testing showed that the RS/Micronta-suggested GWBASIC program is structurally sound and yields consistent, identical results whether run on GWBASIC or QBASIC. Therefore, it appears that one or more parameters may be incorrect. I am suggesting five changes you can try. One change at a time:

#### Change

1. COM1 to COM2.
2. 1200 to 300 (also try 2400, 4800, 9600, 1800, 600, 150, 110, and 75 in place of 1200).
3. N,7,2 to N,8,2 (also try N,8,1 in place of N,7,2).
4. A\$ = "D" to A\$ = "d" (also try other letters A through Z, both upper and lower case, in place of D).
5. INPUT\$ [14, #2] to INPUT\$ [3, #2].

Change #5 presupposes that less than 14 (but at least three) characters were transmitted by your multimeter. If you do get three characters displayed (including any spaces), then you can try the other values 4 through 13.

If there are multiple incorrect parameters, it will be difficult to find them due to the large number of possible combinations. My testing did not address the possibility of inadvertent omission of line(s) of code in the RS/Micronta-suggested GWBASIC program.

For example, the lines A\$ = "D": PRINT #2, A\$ seem to be a command to the meter saying 'read data.' But what if you have to initialize your meter by sending it an "I" before you can 'read data?' Or, what if you have

to send it a "T" to tell it to 'Transmit' to your computer after you have 'read data'?

If none of my five suggested changes to your QB version work, then perhaps it's time to contact RadioShack/Micronta technical support.

Roger Omori  
North Hollywood, CA

#### ANSWER TO #109810 - OCT. 1998

I do not have a schematic for parallel port to IDE, but I can point you to something very close.

Check out the GIDE (Generic IDE interface to a Z80) series of articles available in back issues (#63, 64) of *The Computer Journal*. This is by far the best technical reference to how the IDE interface works.

Check their web site or link to it from the online article "Connecting IDE Devices to 8-bit Machines" from [www.blkbox.com/~jdb8042/SmallSys/8bitIDE.html](http://www.blkbox.com/~jdb8042/SmallSys/8bitIDE.html).

Barry Cole  
Sunnyvale, CA

#### ANSWER TO #11981 - NOV. 1998

The HP Paintjet Printer went out of production in 1993. According to HP, they will stop producing the ink cartridges in July 1999, but to answer your questions on the serial port and switches.

The serial port pinouts are:

Top Side		
60	70	80
30	40	50
10	20	

Pin#	IBM PC	MAC
1	DTR	Handshake Out
2	NC	Handshake In
3	Transmit	Data Negative
4	GND	Signal Ground
5	Receive	Data Negative
6	Transmit	Data Positive
7	NC	General Purpose In
8	Receive	Data Positive



**ANSWER TO #10986 - OCT. 1998**

You did not indicate the type of rotor you have, so the assumption is made that it is one of the common alliance (U-110 types) or Telex (AR-40 type) rotors.

If so, you will not be able to tell direction without the control box associated with these rotors. Both control boxes use a stepper driven directional indicator plate (with arrowed knob) to tell direction.

They usually indicate direction in five-degree increments: S-W-N-E-S clockwise rotation. They will not rotate continuously under limit switch control, beyond 360 degrees, preventing the antenna wire from wrapping around the mast.

In general, the five wires are used for the following:

Ground (1); 24V AC capacitor driven motor lead (1); Stepper mag-

net contact through ground (1); Motor counter clockwise limit through ground (1); Motor clockwise limit through ground (1).

Using an ohmmeter, you can identify the AC motor winding. This lead will be the only high-resistance reading, the remaining switches when closed will be 0 ohms. The AC capacitor is always located in the control box, the stepper contracts operate off of a cam in the rotor

head, reversal of the direction stepper is controlled by contacts on the direction shaft arm.

**Sams manuals** 1191-SED, 1208-SED, 254-T10 may be able to help you and can be obtained by calling **1-800-428-7267**.

**John Lippert**  
Menomonee Falls, WI

**ANSWER TO #11988 - NOV. 1998**

The problem is not with your monitor, but with your video card. There are three components in the display system: the monitor, video card, and the software driver.

A VGA monitor uses analog RGB information, so it can display an essentially unlimited number of colors, so your problem is with the video card or its driver.

Windows setup allows you to select the software driver. A driver disk usually comes with the video card. Windows also includes drivers for several manufacturers (you can get drivers from manufacturer websites).

Examine the video card to find the manufacturer and the model number. Windows has a generic VGA driver that should work for all VGA cards — but it may not handle the resolutions or bit depths that your video card offers.

Using the wrong driver can prevent the monitor from syncing. Selecting a mode (a combination of resolution and color depth) the video card does not support will also prevent sync.

Your VGA card may not support 256 colors — or it may not support 256 colors at the resolution you have selected. The amount of memory on the video card determines the number of colors.

By looking at the card, you may be able to determine the amount of memory. An 800x600 display (0.5 megapixel) with 256 colors (8 bits = 1 byte) requires 0.5 MB of memory. If the video card has only 0.25 MB of memory, then it could only display 16 colors (4 bits = 0.5 byte).

If your video card has some empty sockets on it, then you could add more memory chips to get more colors.

An easier solution is buying a new video card — they should be less than \$20.00 now.

The monitor does not limit the color depth, but it will limit the display resolution because its sync circuits have a limited frequency range.

Your monitor should support 640x480, but it may also support 800x600 and possibly even 1024x768 (SVGA). Your card may produce the correct signals, but your monitor may not support the selected resolution.

**Gerald Roylance**  
Mountain View, CA

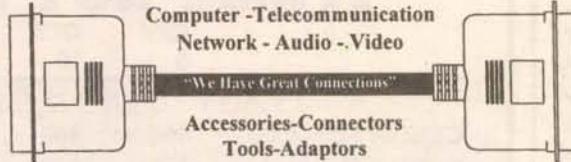
*Continued on page 81*

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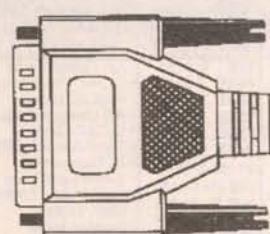
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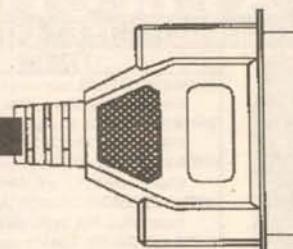
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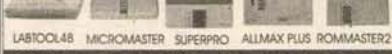
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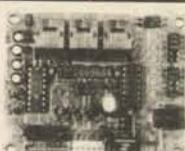
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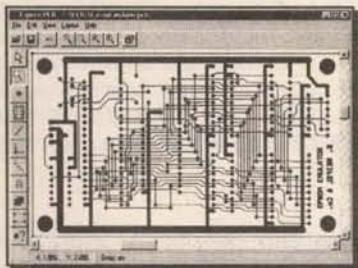
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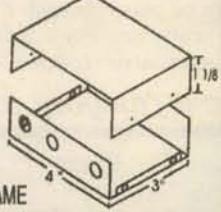
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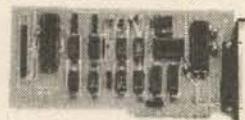
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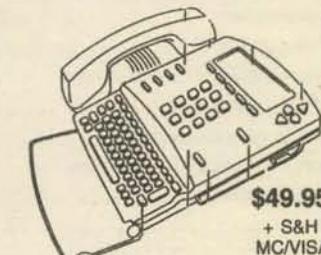
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I'll bet there isn't a single reader of *Nuts & Volts* who isn't addicted to the nitty-gritty of whipping up a new circuit at the workbench. Soldering, etching, loading circuit boards, wiring, and even troubleshooting are the passions of just about all of us electronics aficionados. And, yet many builders shy away from mastering the one aspect of our craft that the layperson notices first: making the thing look nice.

noticed how common rack-mounted equipment is. There's a good reason for this. Rack panels and rack mounts have been standardized by the Electronic Industries Association (EIA). This guarantees that you can mix and match gear, and it'll always fit properly within your cabinets.

Virtually all pro-equipment comes this way. As it turns out, fabricating nice-looking rack panels is actually fairly painless and less expensive than you might imagine.

I can't begin to count the times I've seen a wonderfully designed circuit tossed together helter-skelter into some tattered box with labels looking like they were done by a kindergartner with a crayon! There's no call for this slipshod approach, if you know the secrets.

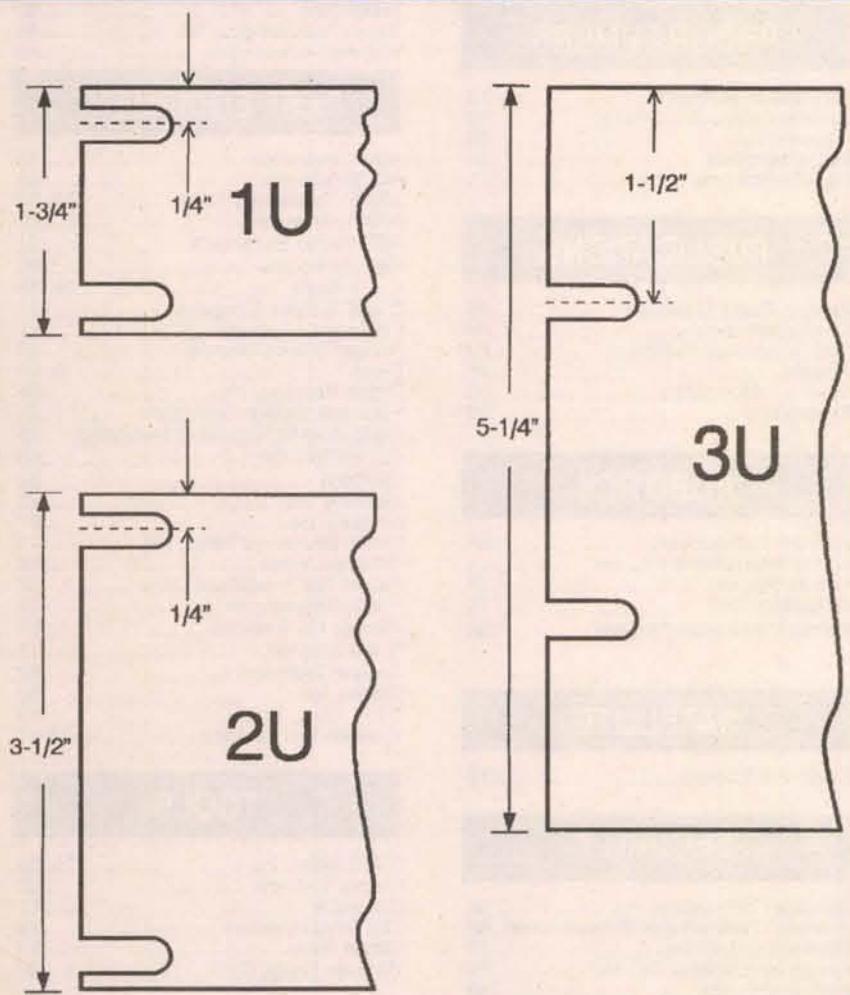
# Secrets of Making Attractive Rack Panels

by Thomas Henry

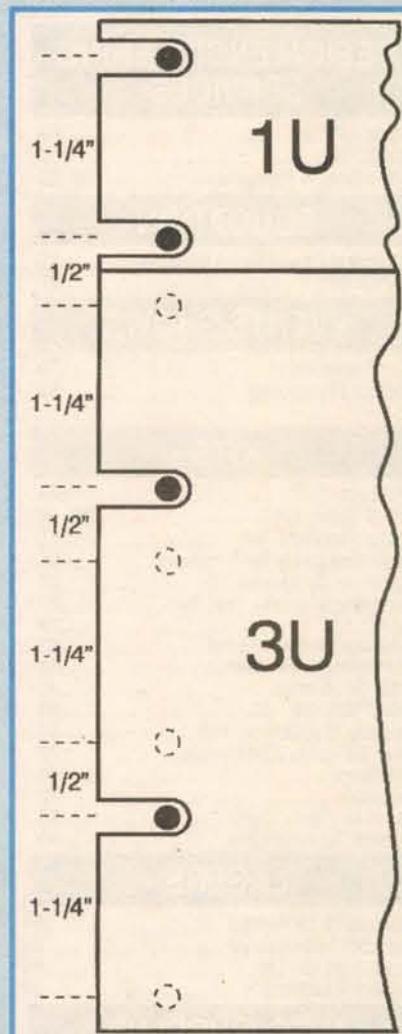
So, let's dive right in and learn all about it.

## RACK PANEL BASICS

As mentioned above, the EIA has specified a standard set of dimensions for rack-mounted gear. These measurements are spelled out in a document entitled, "Racks, Panels, and Associated Equipment," which has been given the reference number of RS-310. (A letter appended to this reference number indicates the current revision of



**FIGURE 1:** Rack panels are always 19" wide, but vary in height by increments of 1-3/4" (called a unit or simply "U"). The three most common are the 1U, 2U, and 3U panels, shown here along with their respective notch spacings. Larger panels follow the same pattern. For example, the next two would be 7" and 8-3/4" in height. The notch spacing from the top and bottom edges is 1/4" for the 1U and 2U panels, and 1-1/2" for the larger panels.



**FIGURE 2:** This figure depicts a portion of a rack mount with two different sized panels installed. Notice how the mounting holes, alternating at 1/2" and 1-1/4" spacing, accommodate the two panels. In fact, this arrangement can handle any combination of standard rack panels, no matter what their respective heights.

the specification.) If you'd really like to read this document for yourself, you can probably find it at a local engineering college library. However, it's not exactly the most lively prose in the world! So, we'll extract the pertinent information here and present it in a more user-friendly fashion. In fact, we'll rely heavily on illustrations to make the details even simpler to grasp.

Standard rack panels are 19 inches wide, but the heights can vary. These heights are specified by the term "unit" or more simply by the symbol "U," which is nothing more than an increment of 1-3/4 inches. So, a 1U panel is 1-3/4 inches high, a 2U panel is 3-1/2 inches high, and so on. See Figure 1.

By the way, one of the reasons the RS-310 document is so tedious to read is that the authors have worked in some "slop factors." As an example of the language you'll encounter there, a 1U panel is dictated to have a height of 1.750-0.031 inches. What this is really saying is that a mass-produced item should be just a little less than perfect. The idea is that if you mount a bunch of these guys next to each other, you want to shave them down a bit so that your cabinet doesn't burst at the seams as you plop them in.

Since we're handcrafting our panels (not mass-producing them), we can be a little more exacting and careful. Hence, all of the measurements used in this article are precise, and completely bypass the "slop factor."

As intimated earlier, you'll be securing rack panels into some sort of overall enclosure. The EIA spec indicates that the mounting holes in the rack panel can be either a "closed slot" (an oval hole) or an "open slot." We'll use open slots since making them only requires commonplace tools like a drill, hacksaw, file, and so on.

Rack panels bolt or screw onto the side railings of a rack cabinet. The railings may be nothing more than one inch by one inch pine strips if you're using wood screws to secure the panels, or might be more sophisticated metal strips tapped to accept 10-32 machine bolts. The mounting holes are separated from each other alternately by 1/2 inch and 1-1/4 inch spacings as shown in Figure 2. A moment's reflection should convince you that this arrangement can handle any combination of standard rack panels.

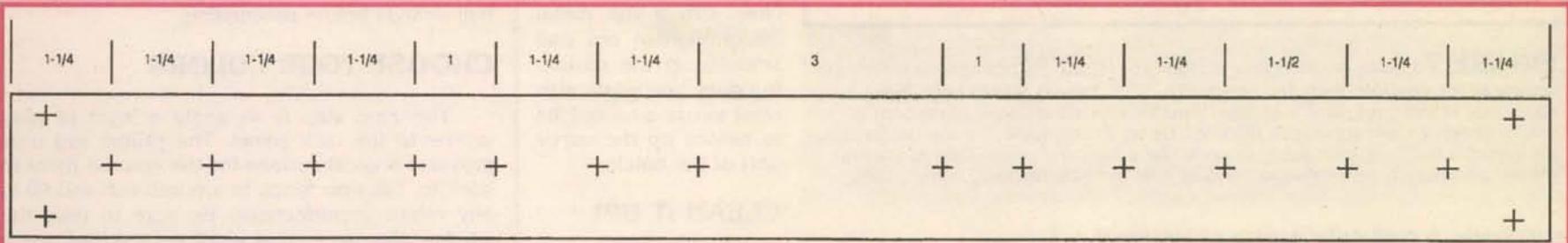
Figures 1 and 2 give us all of the basic theory we need; let's put the theory into practice!

## MEASURE TWICE AND ...

The number one secret of making attractive rack panels can be summed up in a single word: planning. In the old days (i.e., more than 10 years ago), this meant hauling out the mechanical pencil, T-square, and draftsman's triangles. You would then come up with some sort of a layout on a large piece of butcher's paper and hope for the best before your



**FIGURE 3:** With a computer artwork or drafting program, lay out your front panel as in the example shown here. Use reasonable representations of the knobs, switches, jacks, LEDs, and so forth so that you can get a feel for the "ergonomics" of the panel. Allow plenty of finger room between the various controls.



**FIGURE 4:** Once you are happy with your panel design (see Figure 3), replace the representations of the controls, switches, jacks, etc., with cross-hairs, as shown here. This then becomes your drilling guide. If you print it out full-size, you can attach it directly onto a raw panel with masking tape. Use a metal punch to tap a starter divot at the center of each cross-hair, which will keep the drill bit from "walking."

eraser wore out.

Nowadays, of course, we can use the computer to make things really fly along. So, boot up your favorite artwork or drafting program and start planning now! There's scads of drafting software out there (just do a quick search on the Internet and see), but be sure to pick a program that is accurate, includes alignment grids, and can easily place or center geometrical objects.

My number one choice is GeoDraw, which is part of the Geoworks Ensemble package. It's fast, small, and produces superior scaled or 1:1 hardcopy on just about any printer. If this appeals to you, too, check around the World Wide Web where you'll find many links to the program.

So, with your software running and your mouse all warmed up, start trying out some sample rack panel layouts. You'll probably want to have the actual knobs, switches, and other control paraphernalia nearby so that you can check on the spacings. Figure 3 gives you an idea of what you're shooting for. Use lifesize dimensions if your drafting program permits it. This lets you adjust the "ergonomics" as required.

For example, in my own work, I always allow 1-1/4 inches between potentiometer knobs; this leaves plenty of room for your thumb and finger to twiddle a knob without bumping into the next one. Mini-toggle switches are smaller, as are phone jacks, so only one inch is needed to separate these from their neighbors. By the way, all of your projects will benefit if you choose a standard set of "separation dimensions" and use them consistently.

This is also the time to start putting the panel legends or labels into place. Assuming your drafting software has the capability, experiment with different type styles and fonts. Arrange the labels on the layout as though this were the actual unit. Again, using a lifesize representation makes things simpler, since you can tell beforehand if the knobs or mounting

nuts will foul up or obscure the lettering. Take an extra moment to look over Figure 3 once again, which illustrates these concepts. (This is an actual layout from one of my designs.)

Once you are happy with your layout, print it out full-size and examine it from a variety of

that the layout looks right.

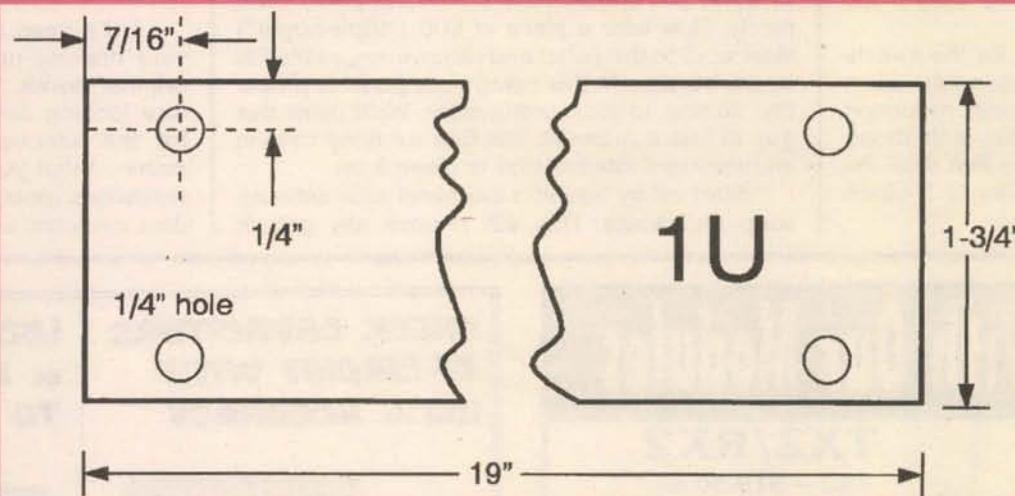
### ... DRILL ONCE

If you like what you see, then save your design to disk. Now make a copy of it with a new name. Alter this copy by replacing the various controls, switches, etc., with cross-hairs showing the center points of each. This becomes your drilling template. Figure 4 gives the general idea.

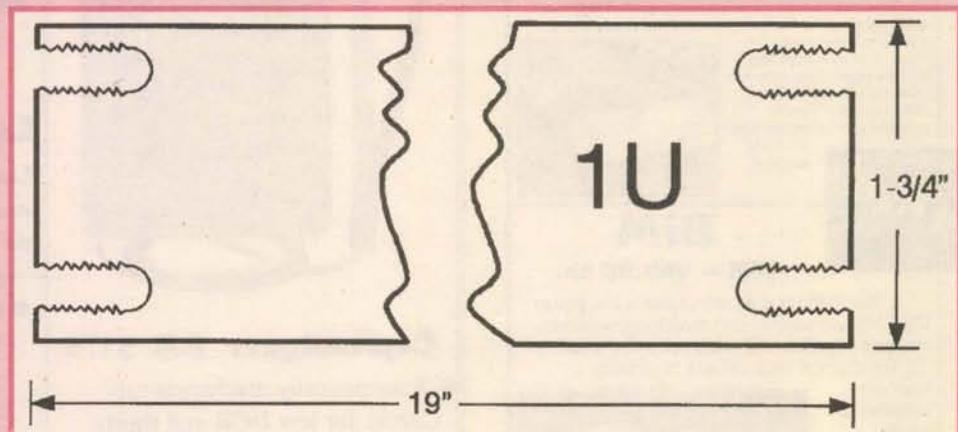
Now, print this version out lifesize. With scissors or a razor knife, cut out the entire drawing and secure it to a blank rack panel using masking tape. With an ordinary metal punch, tap divots into the center of each set of cross-hairs. The starting divot is essential when you begin drilling; this will guide the drill bit confidently and keep it from skating all over the place. When you've completed punching the divots, remove the template sheet and discard it.

And this is probably a good time to pause and say something about the blank rack panel mentioned above. If you check the catalogs, you can find a number of mail order houses willing to supply you with painted and/or punched rack panels in either steel or aluminum. First off, avoid the steel ones completely — your drill bits and hacksaw will thank you! Aluminum panels, 1/8-inch thick, are plenty sturdy and yet easy to work with.

Next, the prices demanded for painted or punched panels will alarm you so much that you might suspect they've been cast in gold! Instead, go for a completely blank panel, 19 inches wide by whatever height you require. You'll cut your own mounting notches and save money, and by painting the panel yourself, you'll not only save again, but get to choose the color scheme you like best. By the way, don't be concerned if the raw panel has surface blemishes or oxidation on it; a later step will clean these up



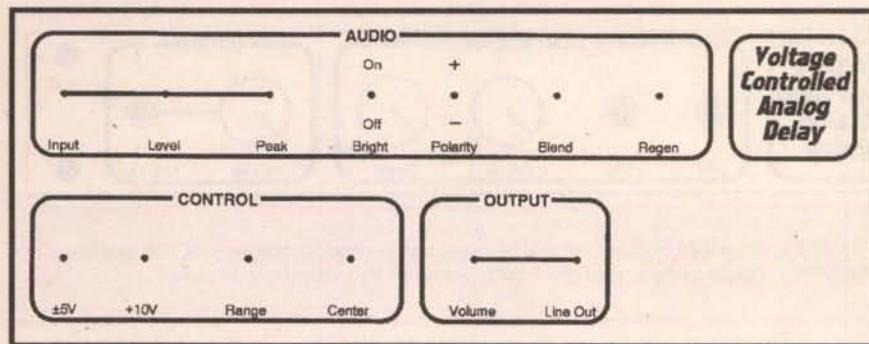
**FIGURE 5:** The first step in notching a rack panel is to drill 1/4" holes in the four corners. The alignment of the holes is always 1/4" or 1-1/2" from the top or bottom edges (see Figure 1 for details). The 1U panel shown here has its holes 1/4" from the edges.



**FIGURE 6:** Next, the slots are cut out roughly using a hacksaw. Be sure to make them slightly smaller than required. Then with a flat metal file, smooth out the cuts and enlarge the slots appropriately. Keep them neat, straight, and free of burrs.

angles. Since rack panels are 19 inches long, this implies that things will be simpler if you print the hardcopy lengthwise down a continuous sheet of tractor feed paper. But if you're using a laser printer with single sheet feed, you can always tape successive pages together. In any event, spend some time now convincing yourself

wide by whatever height you require. You'll cut your own mounting notches and save money, and by painting the panel yourself, you'll not only save again, but get to choose the color scheme you like best. By the way, don't be concerned if the raw panel has surface blemishes or oxidation on it; a later step will clean these up



**FIGURE 7:** Using your original design (see Figure 3), replace the representations of the controls, switches, jacks, etc., with dots, as shown here. Make a hard copy of the page, and then have your local printing house photocopy it onto a sheet of clear stick-back material. Using a razor knife, cut the decals out. Remove the backing, then apply them to the drilled and painted panel. Line-up the decals properly by centering the dots over the various holes in the panel.

completely. A mail order source of inexpensive blank rack panels is listed in the Resources.

But back to the workbench. You're all set to start drilling the holes required by the project. Your first step should be to drill pilot holes in the center of each of the divots you punched earlier. A small bit, like a 3/32 inch, is good for this. And be sure to secure the rack panel firmly in place to a piece of scrap lumber using a C-clamp before beginning to drill. Once the pilot holes are in place, you can then drill the actual control fittings; the pilot hole will keep the larger bit centered and preclude it from walking around the panel.

So, you've now got the holes for the switches, pots, LEDs, and other components taken care of. What about the rack panel mounting slots? Another 15 minutes will dispatch these. Refer to Figure 5 which shows the first step. As illustrated there, you begin by drilling a 1/4-inch hole in each of the four corners.

Then, with a hacksaw, cut notches into the four holes you just drilled. (A workbench vise is a great aid here.) Figure 6 gives the general idea. These will be a little rough around the fringes, and so should be sawed just a trifle smaller than required. Now with a flat metal file, straighten out and smooth up the mounting slots. You might also want to use a rat tail file to neaten up the curvy part of the notch.

### CLEAN IT UP!

Well, if everything has gone according to schedule you now have an aluminum panel fully cut and drilled to accept the various controls and switches. And the mounting slots permit it to be slipped into a cabinet for permanent use. The only trouble is that the front surface is a bit scuffed here and there, and other blemishes may detract from the general appearance. That's easy to deal with!

Slip a piece of fine grit sandpaper into an electric sander and have at it! After three minutes of work, you should have buffed the panel quite nicely. Now take a piece of 000 ("triple-aught") steel wool to the panel and remove any swirls left by the sander. At this point, your panel is probably starting to look pretty silky. We'll paint this guy in just a moment, but first we need to take an important intermission to clean it up.

Start off by washing the panel with ordinary soap and water. This will remove any grit or

debris left from the sanding and steel wool steps. Really suds it up well, and rinse it thoroughly afterwards. Give the panel a quick dry off with a soft towel.

We need to get rid of any remaining soap film or residue now. So, using cotton balls and 90% alcohol (available at any drug store), give the panel a thorough cleansing. The alcohol will remove any lingering soap scum completely. Let the panel air dry, then buff it down one more time with a soft, dry towel. Check for any lint or cotton ball strands before proceeding.

### CHOOSE YOUR COLORS

The next step is to apply a layer of gray primer to the rack panel. The primer not only provides a good surface for the colored paint to stick to, but also tends to smooth out and fill in any minor imperfections. Be sure to read the label on the can so that you'll get the best possible results out of the gray primer.

Once the primer is dry, you can apply the colored spray paint layer. The top choice here is probably epoxy paint (the kind used on household appliances). Epoxy paint provides an extremely tough surface, immune to most chipping and scuffing. Again, be sure to follow the instructions on the can carefully, and allow plenty of drying time.

### LABELING THE PANEL

Let's head back to the computer. Boot up your drafting program again, and load in your original layout. We'll use this to whip up some nice looking decals which will provide a legend for the various controls. Figure 7 gives the details. What you do is replace all of the representations (pots, jacks, switches, etc.) with black dots centered over each fitting. The reason for

## Go Wireless With Our Modules

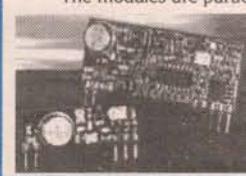
### SILRX/TXM

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TXM — \$15.50 ea.

The TXM and SILRX modules are a transmitter and receiver pair which can achieve a one-way radio data link-up to a distance of 200m over open ground.

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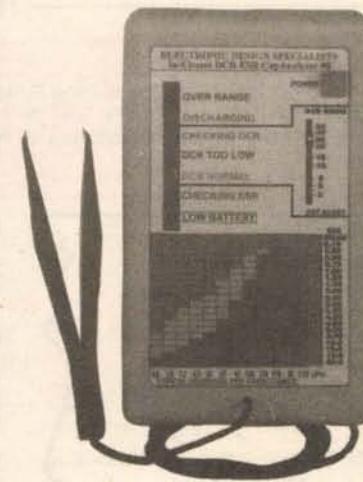
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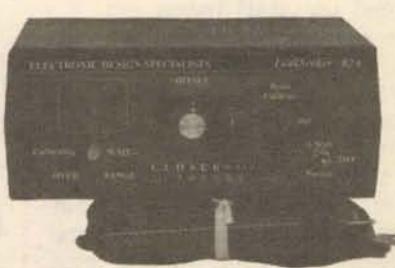
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this will become clear in just a moment. Now using the "cut and paste" command within your software, rearrange the major groupings so that they'll all fit on an 8-1/2-inch by 11-inch sheet of paper. If you're satisfied with how things look, print it out, using a laser printer for best results.

Take the page to your local photocopy shop and have the folks there reproduce it onto a sheet of clear sticky-back material. (This is a self-adhesive transparent plastic sheet which comes in either shiny or matte finishes.) Alternatively, if you have a stock of blank sticky-back sheets yourself, you could run them through your laser printer directly and skip the photocopying step.

Next, using a sharp razor or X-acto knife, cut out the decals in logical blocks. For example, in Figure 7, there are four logical blocks, or you could lump the top two together and the bottom two together. In any event, peel off the backing of the decal and press it down on the panel. The dots help you line it up over the holes you've already drilled. To avoid trapping air bubbles under the decal, it's usually best to start at one end and carefully work your way along the length of the decal. Then place a sheet of paper over the decal, and with the back of your thumbnail rub it down smoothly to press out any air bubbles.

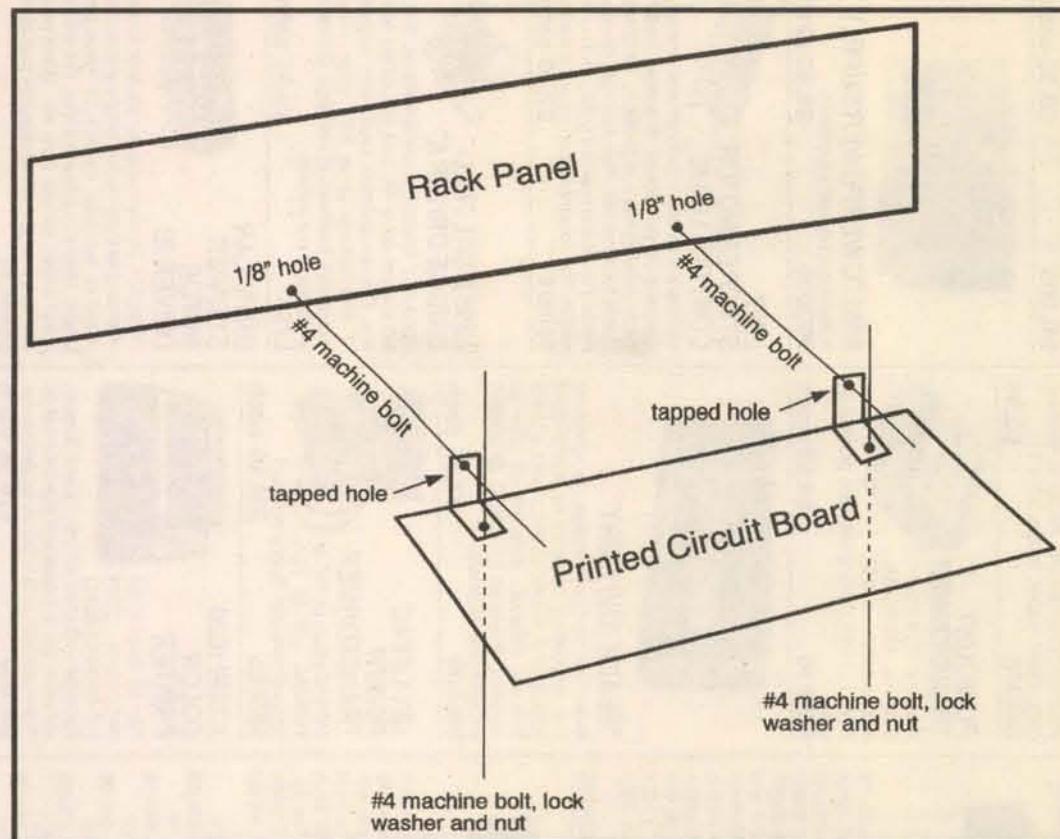
At this point the decals cover everything, including the holes! So, with a pointed X-acto knife carefully cut out the center of each one. That is, stab the knife into a hole, then slide it around the perimeter trimming away the sticky-back material. When you make it all the way around, a disk will pop out which you then discard. Repeat for all of the remaining holes.

To really protect your handiwork, you need to apply a layer of clear plastic spray paint. But here's an important point. Spray it on in many, many thin layers (allowing time to dry between each layer), instead of several thick layers. This not only keeps the "ink" from running, but also prevents swirls and runs from rearing their ugly heads.

## USING YOUR PANEL

Give the clear coat a couple days to really dry, and then you're all set to start building with your new rack panel. For most common circuits, you can simply mount the circuit board behind the rack panel on little angles. Figure 8 illustrates how to do this. (On the other hand, RF or high-voltage circuits should probably be housed in something that isolates them completely from the outside world.)

When you're all done with the wiring and testing, you can mount the completed unit in a cabinet. As mentioned earlier, if your cabinet has wooden rails you can use wood screws for this; tapped metal rails require a 10-32 machine bolt. If you have a choice of head type, pick the oval style. That way, you



**FIGURE 8:** A printed circuit board mounts behind the front panel by means of two small angle brackets. The front holes of the brackets have been tapped to take #4 machine bolts, while the bottom holes accept #4 bolts, lock washers, and nuts.

can use cup washers between the screw or bolt and the front panel; the oval head "settles in" to the center of the cup washer quite nicely and looks very professional. They are available in several sizes and materials (brass, aluminum,

this process, I have had a steady stream of compliments from people on how attractive my gear appears.

If I (with a total lack of a background in art) can do it, then so can you! **NV**

## RESOURCES BLANK RACK PANEL KITS

Blank rack panel kits are available from **Midwest Analog Products** in either 1U or 2U sizes. Each kit includes: blank aluminum rack panel, 1/8" thick tapped miniature angles zinc plated #4 machine bolts, lockwashers and nuts. #K901 1U (1-3/4" by 19") Rack Panel Kit \$8.95 #K902 2U (3-1/2" by 19") Rack Panel Kit \$10.95

Note the following ordering information:  
Minimum order of \$15.00. Please add shipping and handling of 10% of merchandise total or \$5.00

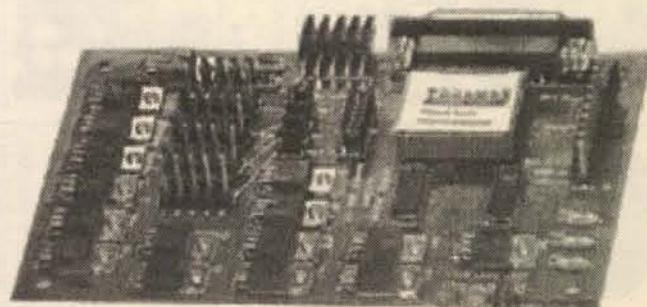
(whichever is less).  
Shipping is by First Class Mail.  
Prices shown in US dollars. Remit US funds only. Write or E-Mail for shipping information to other countries. MN residents add 6.5% sales tax.  
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nickel-plated, etc.) at most hardware stores.

And here's an idea I came up with to keep the cup washer from marring the front surface of the rack panel. While you're still at the hardware store, head over to the plumbing department.

There you'll find a large range of rubber O-rings (for fixing faucets and so on). I discovered that there are sizes of these that fit perfectly in the back (hollow) side of the cup washer!

Thus, when you secure the panel in place, the screw passes through the cup washer, then the O-ring, then the panel, and finally the cabinet rails. The rubber cinches everything together nicely and protects the panel from the sharp edges of the cup washer.

If you've come this far, then you now know the secrets of making truly decent-looking rack panels for your own equipment. Over the two decades that I've been using and refining

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The RF power reading is not linear and simply indicates the presence of RF and its relative level. However, it makes a great BUG detector or you can use it to test the output of any RF transmitter, including ham radios, cordless telephones and even car alarm transmitters! The circuit has an adjustable attenuator to handle everything from low to high power levels. Use during RFI/EMI precompliance testing. The kit is easy to assemble and comes with schematic diagrams and complete instructions.  
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RC3120C - Front panel 19" x 3.4375" x 3.25" H x 16.625" W x 13.1875" D - \$53.00

RC3120D - Front panel 19" x 5.1875" x 5" H x 16.625" W x 13.1875" D - \$58.00

RC3120E - Front panel 19" x 5.1875" x 5" H x 16.625" W x 16.75" D - \$63.00

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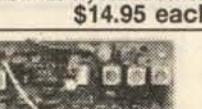
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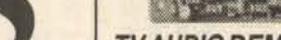
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by Joseph J. Carr

# Open Channel

## Antenna Gain and Pattern Measurements

One way to characterize radio antennas is by their radiation pattern. When a signal propagates from an antenna, it radiates in some directions more than others. A theoretical construct called an isotropic source is a spherical point source that radiates in all directions. An antenna shows an apparent increase in power in preferred directions because the power that is spread over the isotropic surface is concentrated in the preferred direction. This is the gain of the antenna. The gain of an antenna in any given direction is found essentially by comparing the signal strength in that direction to the signal strength of the same unit area on the surface of the radiating isotropic source. This is called gain over isotropic, and is expressed in decibels (dB).

When we make a map of the gains in all directions, we have the radiation pattern of the antenna. The overall radiation pattern is a solid, three-dimensional geometric figure, so we often take horizontal

("azimuthal") and vertical ("elevation") slices out of the pattern and present them as representative of the whole.

Figure 1 shows the radiation pattern for unidirectional Yagi-uda array designed for 151 MHz, where it can be used for solar noise detection. Ideally, the Yagi-uda is unidirectional, but "real world" antennas are not so fortunate. In this case, there is a considerable back lobe and several side-lobes in addition to the main lobe. Any lobe in an unwanted direction results in wasted power (lower signal strength on target), greater possibility of interfering with other stations and (because of antenna reciprocity), more noise and interference on receive. Clearly, the antenna designer and user needs to know the nature of the azimuth and elevation patterns.

### Outdoor Tests

Figure 2 shows an outdoor method for measuring the antenna

radiation pattern. It is fraught with difficulty, but is sometimes the only means available for a particular antenna or location. Although it's best to use an indoor antenna range (discussed below), those facilities are both expensive and frequency limited. All such facilities have a lower frequency cut-off limit, below which it will not work properly.

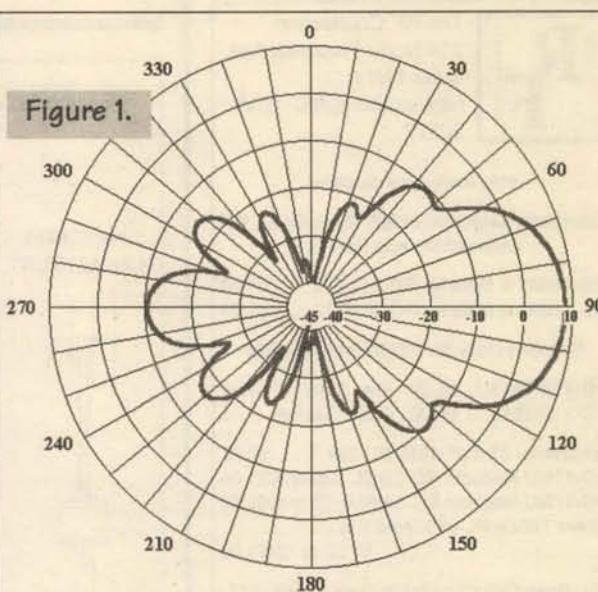
In Figure 2, the antenna under test (AUT) is mounted to a rotator assembly.

A distant source, perhaps a distant on-the-air radio station, is used to provide a signal source. The signal source must be in the far-field, i.e., where the power density falls off according to the inverse square law ( $1/D^2$ ). The pattern can be obtained by rotating the antenna through a 360-degree arc, and measuring the signal strength at points along its arc of travel.

This process is easy, intuitive, and inherently appealing. But it is also problematical. For one thing, in the off-the-air variation on this theme, there is no guarantee that the output power of the distant radio station is constant during the time the antenna is rotating.

Some of the ambiguity can be

taken out of the outdoor test approach by using a known reference signal, rather than an off-the-air signal. If a signal is generated, and controlled to maintain a constant output level, then part of the problem is solved. In general, the best approach to having the signal provide uniform illumination of the antenna is to radiate it from a location outside the near field of the antenna, from a transmitting loop antenna that is small compared with the wavelength of the signal being emitted. A loop that is  $<0.15\lambda$  has the attribute of exhibiting a constant current throughout the conductor. Larger loops, and other forms of antenna, have a varying current distribution along the length of the



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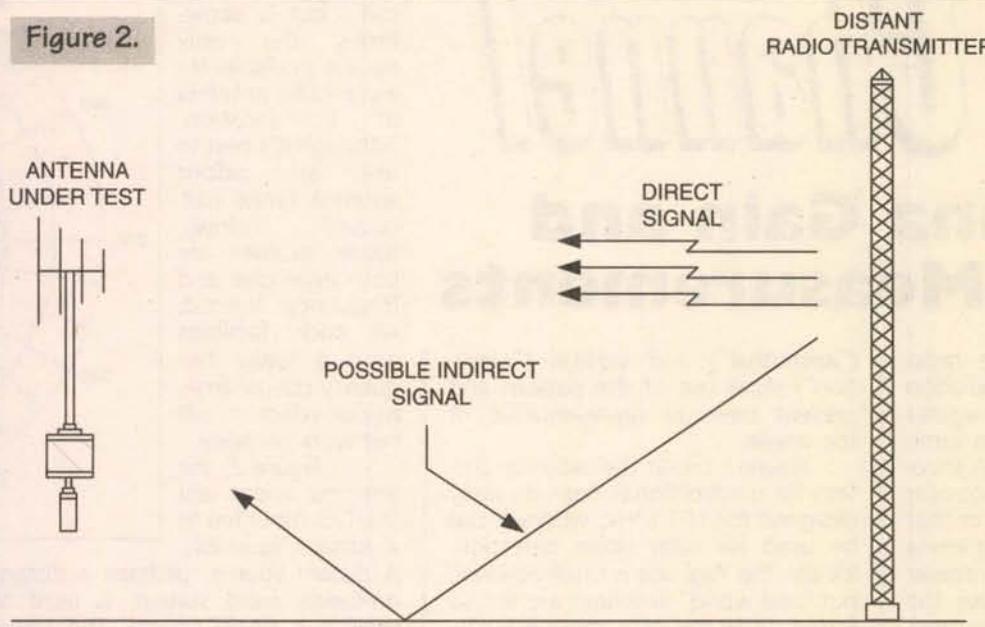
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## Open Channel

Figure 2.



antenna radiator.

Also, unless it is a broadcasting station, it is likely to go on and off the air with use rather than emitting a constant signal. In the high frequency shortwave bands, this problem can be especially acute because of fading mechanisms afflicting even groundwave signals. With skywave sources (ionospheric propagation aka "skip") it is insanely difficult to account for!

Another problem is unwanted signal paths. Normally, one hopes that only the direct space wave is received. That would make the problem easier. But in real environments there may be additional paths. In Figure 2, a ground reflection is shown. It is sometimes easy to overcome these by being aware of their source and adjusting the data accordingly. Unfortunately, nice static ground reflections are not the only sort found. Especially at VHF/UHF, there may be transient reflections due to passing ground vehicles and aircraft. Supposedly, sometimes even good-sized birds can be a problem.

All in all, the outdoor method is perilous, at best. But before moving on to discussing the indoor range approach, let's take a look at a quick and dirty approach to making gain

measurements.

Figure 3 shows two antennas pointed at the same distant source. It is relatively easy to achieve a reasonable approximation of the antenna gain by comparing it to a reference antenna. For most purposes, either a half wavelength dipole or a quarter wavelength vertical antenna is preferred for the reference antenna.

The basic procedure is simple and straightforward. Let's assume that the AUT has a higher gain than the reference dipole. Set S1 to measure the signal strength coming from the reference antenna. Next, switch S1 to the AUT and again measure the signal strength.

If the receiver used has the ability to accurately measure the two signal levels, then a gain determination can be made. If the receiver is merely a communications receiver with an S-meter, then there may be problems if either: a) the S-meter calibration scale factor is unknown, or b) the scale factor changes over the range (some S-meters compress the upper end of the scale, so the difference between S8 and S9 is fewer decibels than the difference between, say, S1 and S2, despite the fact that both are "one S-unit"). In that case, a modified procedure is used:

1. Set S1 to measure the signal strength from the reference dipole.

2. Set S1 to measure the signal strength from the AUT (it should be higher).

3. Adjust the precision attenuator in the transmission line from the AUT until the S-meter reads exactly the same as it did for the reference dipole.

One instruction for this method took note of the fact that the signal levels might vary over time, so switching between antennas can introduce error. The problem is partially solved by switching the antenna at

a slow enough rate to capture the data, and taking a large number of samples (e.g., one per second over several minutes) and averaging the results.

## Indoor Range

If the funds and facilities are available, then an indoor antenna range (Figure 4) is preferred. The data collected are of far greater usefulness than the data collected out-of-doors, especially off-the-air. The indoor range is simply a more easily controlled, predictable environment.

The indoor range consists of a room lined with materials that absorb radiowaves. Usually in the form of pyramid-shaped wedges, various sizes of absorbers are placed over all surfaces of the chamber. The room is inside of a Faraday cage. This shielding provides protection against both signals from outside interfering with the test, and reflections of the reference signal from structures outside of the chamber. A point source, such as a small loop at UHF and below, or a horn radiator at microwave frequencies, is positioned at one end of the room.

The antenna is mounted on a rotatable pedestal. In order to

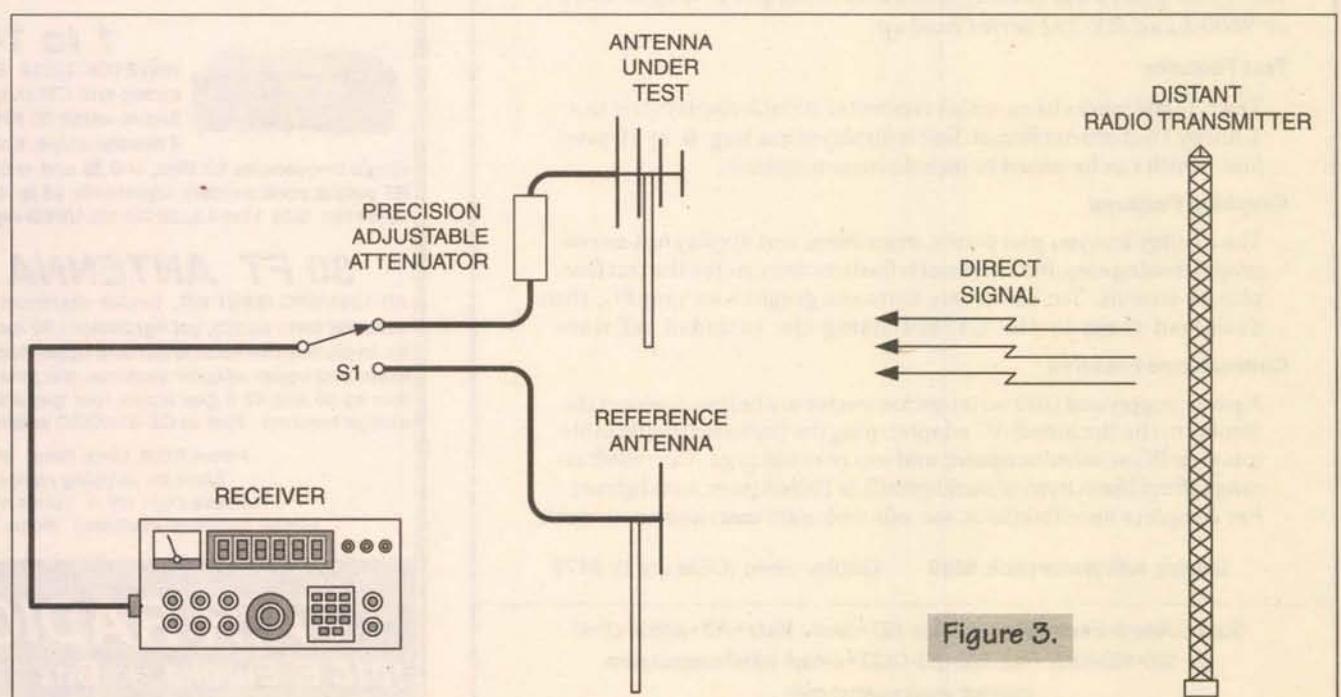


Figure 3.

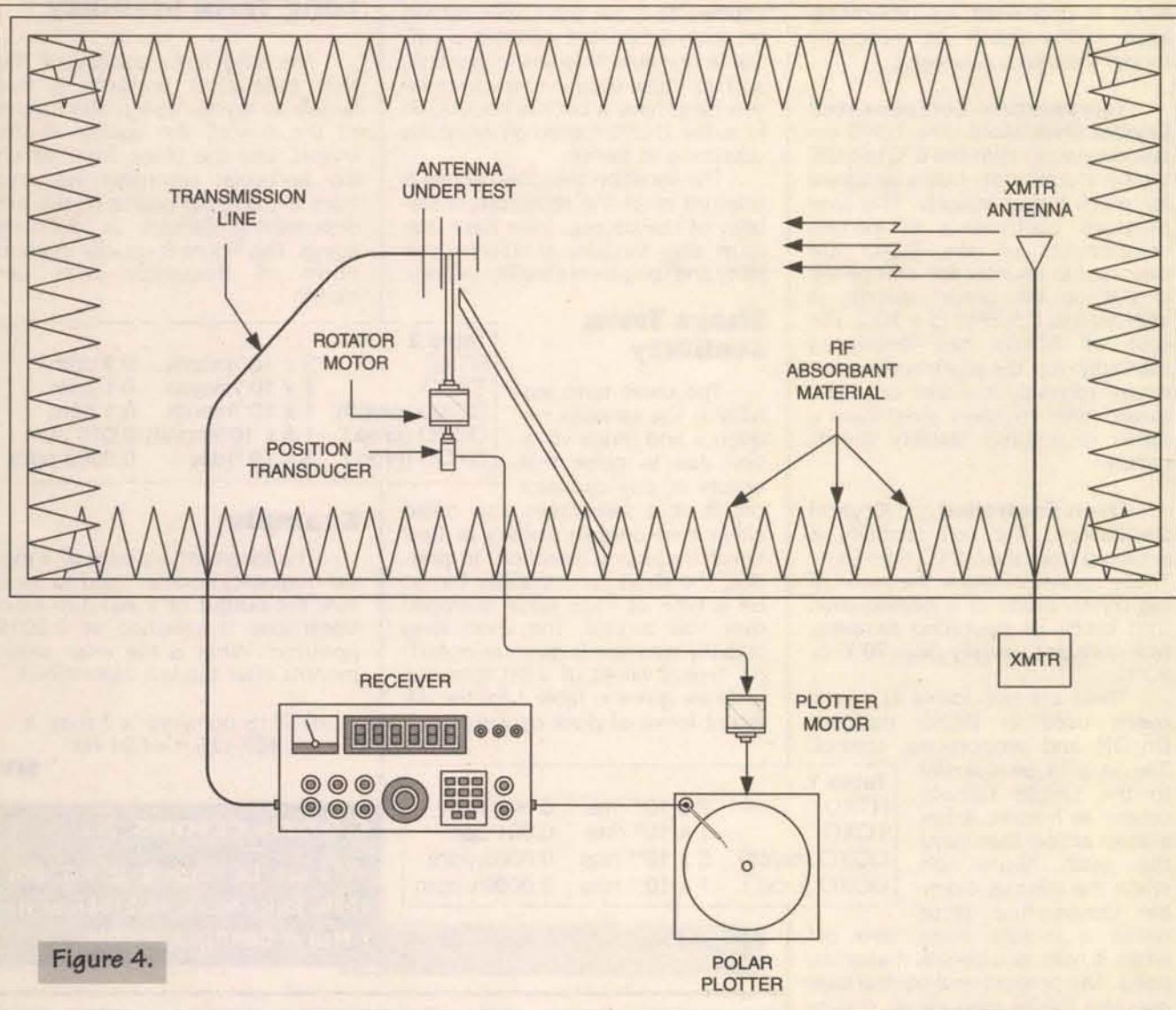


Figure 4.

prevent secondary reflections from the pedestal, it is often the case that blocks of absorbent material are used to block the view of the pedestal from the radiator. Both elevation and azimuth plots can be made by the simple expedient of mounting the antenna in the correct plane for each test.

The polar pattern of the antenna is created by using a servomotor or position transducer to rotate a chart recorder that measures the output strength of the receiver. The result is an antenna position-signal strength plot similar to Figure 1.

Modern versions of the indoor range use a computer rather than the polar plotter shown in Figure 4. The output of the receiver is a voltage indicating signal level, so it can be A/D converted for input to the computer. The position transducer can also provide data to the computer. Once these data are in, a plotting program can draw the polar plot.

One advantage of the computer approach is that a static profile of the chamber can be made by mounting a reference antenna in place of the AUT. The plot can then be made, and note taken of any reflections or other anomalies that exist in the chamber. These data can then be compared with the data for the AUT at each angle, with the AUT data adjusted to account for directional differences.

#### Antenna Modeling

Antenna chamber time can be expensive, so the trend today is to model the antenna performance on

the computer before doing any actual building and testing. At one time, it was common to perform range tests, and then tweak the antenna design to improve the performance (often with inconsistent results). Antenna modeling provides a lower

cost approach to tweaking performance, with range time reserved for final confirmation. I have discussed antenna modeling in this column in the past. My own modeling is done with the Nittany-Scientific Nec-Win Basic program.

#### Other Ways to Solve the Problem

There are a couple of other ways to find the antenna pattern, or at least a rough approximation of it. For many years, radio broadcasting stations were required to do "proof of performance tests" that showed the radiation pattern. As part of the initial construction of the station, they would go to specified points on a map, and measure the field strength. If enough points "all around the compass" are measured, then a rough approximation of the pattern is made.

The AM broadcast band station is one area where this must be done. Antennas are hundreds of feet high, so are not very easy to measure in chambers! Besides, the point is the "installed" behavior, not the in-chamber behavior. This same thing can be done by amateurs and others. Use a topographic map (not a road map). These are available from the US Geological Survey. They have stores in locations around the country, and their products are also sold by commercial map dealers. Locate the antenna on the map, and make a dot.

Next, take a drawing compass, and spread the arms to make a radius equal to one mile on the map. Draw a circle with the antenna location at the center. Next, pick 30 to 60 points along the circle, and then travel there and measure the signal strength. Crude? Yes, but a reasonable idea of the antenna pattern can be obtained.

Another method for measuring the antenna pattern was used by a friend of mine down in Texas. Johnnie owned a small farm (43 acres) that he used for making antenna experiments. He also owned a 1946 Taylorcraft airplane. It was a kit-built variation on the Piper Cub style design. He owned a Stoddard field

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strength meter that could be set in the passenger's seat. John would fly a circular route around his farm, about five miles out, with the field strength meter tuned to the transmitter frequency.

He would use a handheld two-meter walkie-talkie to ask a friend at his home station to key the transmitter that excited the test antenna. When the transmitter came up, he would mark his location and the FSK reading on the map.

### Crystal Oscillator Accuracy and Stability

In the past several months, I've answered several questions on crystal oscillator specifications for the readers of this and other publications. The terms that seem to be most popular are accuracy and stability. The accuracy is the measure of the difference between the design or marked frequency and the actual frequency. Accuracy is measured in parts per million (PPM) or percent. A Citizen's Band transmitter is supposed to be within 0.005 percent of the design frequency, which is the same thing as 50 PPM. At 27 MHz, that works out to  $\pm 1,350$  Hz.

The stability of the oscillator will profoundly affect the accuracy over time. With respect to accuracy and stability, there are three basic categories of crystal oscillator: room temperature crystal oscillators (RTXO), temperature-compensated crystal oscillators (TCXO), and oven-controlled crystal oscillators (OCXO).

**Room Temperature Crystal Oscillators.** The RTXO takes no special precautions about frequency drift. But with proper selection of crystal cut, and reasonable attention to construction, stability on the order of 2.5 parts per million (PPM),  $2.5 \times 10^{-6}$ , over the temperature range 0°C to 50°C is possible. The

RTXO is only used for non-critical applications (such as economy model frequency counters).

**Temperature-Compensated Crystal Oscillators.** The TCXO circuit also works over the 0°C to 50°C temperature range, but is designed for much better stability. The temperature coefficients of certain components of the TCXO are designed to counter the drift of the crystal, so the overall stability is improved to 0.5 PPM ( $5 \times 10^{-7}$ ). The cost of TCXOs has decreased markedly over the years to the point where relatively low-cost upgrades to economy counters gives them a rather respectable stability specification.

**Oven-Controlled Crystal Oscillators.** The best stability is achieved from the OCXO time base. These oscillators place the resonating crystal inside of a heated oven that keeps its operating temperature constant, usually near 70°C or 80°C.

There are two forms of crystal ovens used in OCXO designs: On/Off and proportional control. The on/off type is similar to the simple furnace control in houses. It has a snap action that turns the oven heater on when the internal chamber temperature drops below a certain point, and off when it rises to a certain maximum point. The proportional control type operates the heating circuit continuously, and supplies an amount of heating that is proportional to the actual temperature difference between the chamber and the set point. The on/off form of the oven is capable of 0.1 ppm ( $10^{-7}$ ).

OCXOs that use a proportional control oven can reach a stability of 0.0002 PPM ( $2 \times 10^{-10}$ ) with a 20-minute warm-up and 0.0001 PPM ( $1.4 \times 10^{-10}$ ) after 24 hours. It is common practice to design the

counter to leave the OCXO turned on even when the counter is off. Some portable frequency counters, such as those used in two-way radio servicing, have a battery back-up to keep the OCXO turned on while the counter is in transit.

The variation described above is referred to as the temperature stability of the counter time base. We must also consider short-term stability and long-term stability (aging).

### Short Term Stability

The short term stability is the random frequency and phase variation due to noise that occurs in any oscillator circuit. It is sometimes also called either time domain stability or fractional frequency deviation. In practice, the short term stability has to be a type of RMS value averaged over one second. The short term stability measure is given as  $\sigma(\Delta f/f)$  (t). Typical values of short term stability are given in Table 1 for the different forms of clock oscillator.

Table 1

RTXO	$2 \times 10^{-9}$ rms	0.002 ppm
TCXO	$1 \times 10^{-9}$ rms	0.001 ppm
OCXO (on/off)	$5 \times 10^{-10}$ rms	0.0005 ppm
OCXO (prop.)	$1 \times 10^{-11}$ rms	0.00001 ppm

Table 2

RTXO	$3 \times 10^{-7}$ /month	0.3 ppm
TCXO	$1 \times 10^{-7}$ /month	0.1 ppm
OCXO (on/off)	$1 \times 10^{-7}$ /month	0.1 ppm
OCXO (prop.)	$1.5 \times 10^{-8}$ /month	0.015 ppm
OCXO (prop.)	$5 \times 10^{-10}$ /day	0.0005 ppm

### Example

The long-term stability of a digital frequency counter used to measure the output of a 467.125 MHz transmitter is specified as 0.0015 ppm/mo. What is the error seven months after the last calibration?

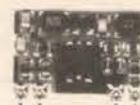
$$\pm 0.0015 \text{ ppm/mo.} \times 7 \text{ mos.} \times 467.125 = \pm 4.91 \text{ Hz}$$

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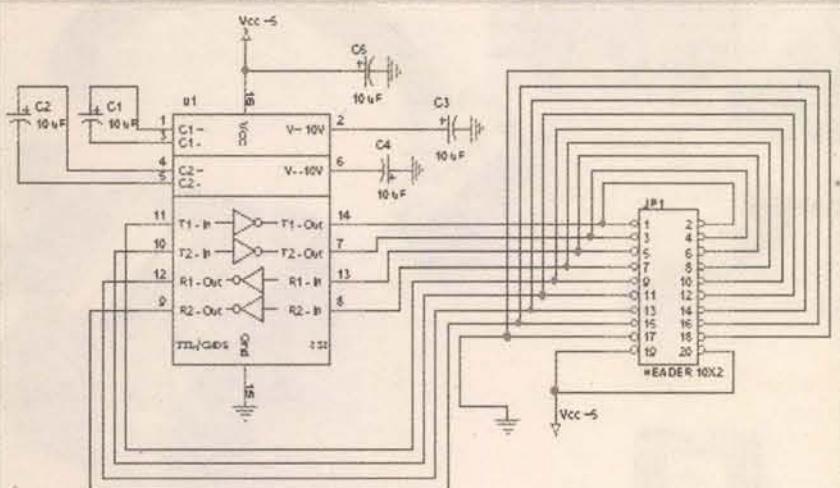
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# TECH FORUM

Continued from page 66



## ANSWER TO #10983 - OCT. 1998

DEC terminals are a little non-standard, but quite usable for the task at hand. My experience has been with the VT100-320, but I'll wager they're quite compatible.

The D-Type connector is probably a DEC standard DE-9. It will probably be easiest to just solder in the right angle connector (Jameco lists three different depths measured from the base of the connecting portion to the first row of pins, the depths are .318", .450", .590"; they are 8 to 59 cents each.)

Unlike IBM, DEC kept the critical pins 2, 3, and 7 at those same pin numbers when converting from 25-pin to 9-pin adapters.

To convert it to a DTE, the following pinouts are used:

### DEC 9-PIN > 25-PIN ADAPTER 9-PIN SIDE 25-PIN SIDE

2	3
3	2
4	5
5	6
7	7
6	20

The DEC-type connector you inquired about is an RS-422 port. It is just a standard six-pin modular jack with its tab offset so you can't accidentally plug in a phone line.

The crimp-on plugs for this were hard-to-find and expensive in its heyday. I doubt it would be worth the effort. But if the soldering is intimidating, you can produce one of these connectors by shaving the tab off a standard six-pin mod plug.

Art Popp  
via Internet

The outputs from the plug are differential. So you will have to tie T- and R- together to make a Signal Ground, and use T+ and R+ as Tx and Rx. A small, well-stretched piece of electrical tape applied around the body of this plug should "fatten it up" enough to stay securely in the hole.

Once you have the terminal typing back and forth with your computer (through a null-modem cable if you used the DE-9 converter). The rest is a snap.

All you need is a serial line level converter like the famous MAX232. This converts the 0-5 volt signals from your 8051 to  $\pm 10$ , for the terminal.

Below is a circuit based on the reference design. It sets up the chip correctly and pulls the signal and power pins out to a 20-pin header. If you mount the header on the bottom side of the board you can just plug this into your breadboard whenever needed.

### Jameco Part #s

DE9P318	Male 9-pin connector .318 set back
DE9P590	Male 9-pin connector .590 set back
DE9P450	Male 9-pin connector .450 set back (not listed, but may exist)
79273	6-pin mod plugs
24811	MAX232CPE
93577	10 uF Caps
53479	Dual row 20-pin straight male header

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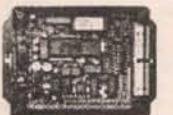
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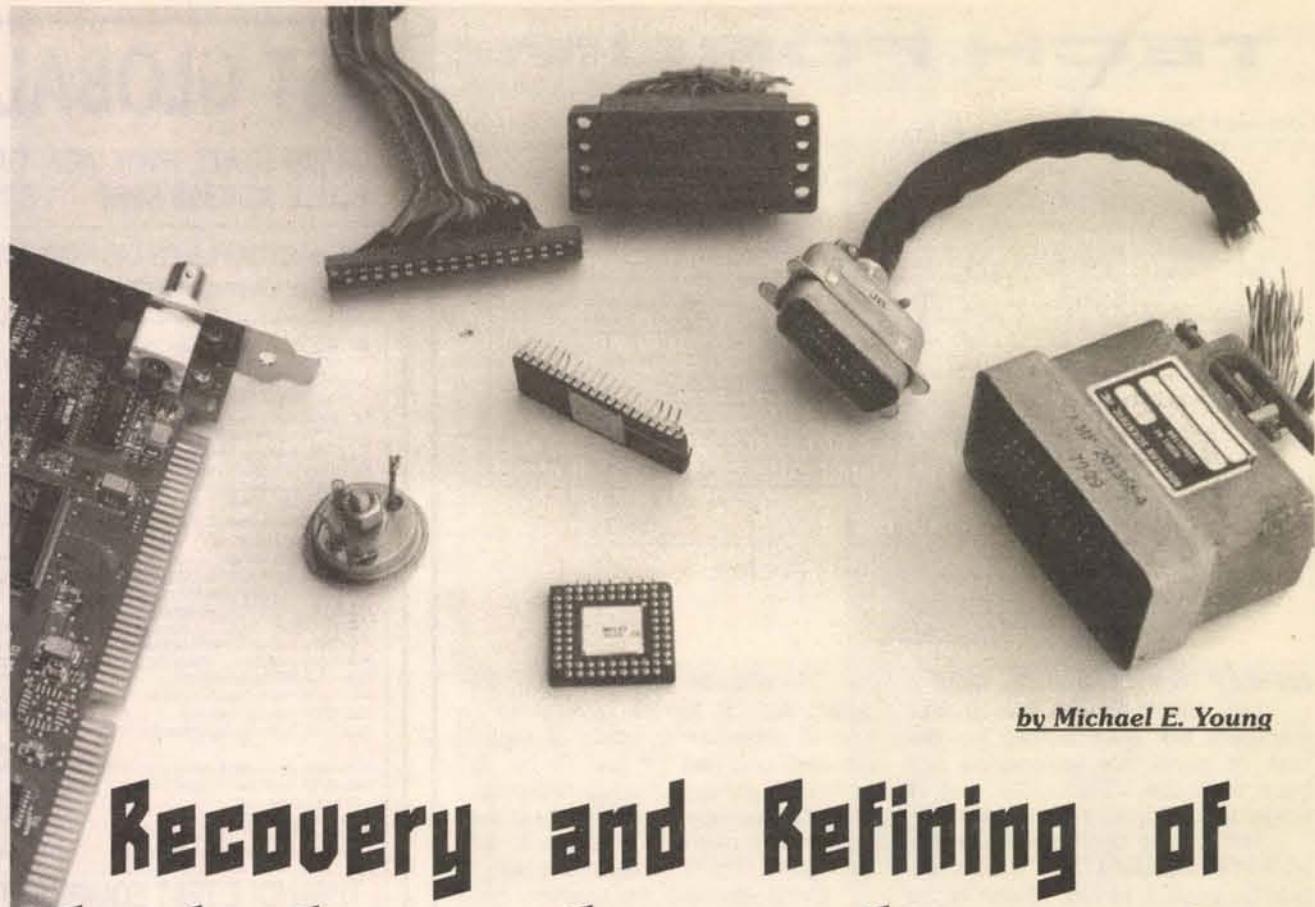
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by Michael E. Young

## Recovery and Refining of Gold From Scrap Electronics

### Introduction

Probably the most lucrative area in recycling today is in the recovery of precious metals. In this article, we will discuss the recovery of gold from scrap electronics and demonstrate a method you can use to recover gold on a small scale in your own backyard.

Finding gold-containing components is really not very hard. The basic rule you should remember is that if it looks like gold, it is gold. Don't become overly concerned with how much gold is contained in components you can't see. There are plenty of sources of visible gold available. This article describes just one method (there are others) to recover gold and is written on a scale intended for the hobbyist.

The procedure given in this article requires the use of some chemicals that are very dangerous and will require some care and preparation on your part. **So read the section on safety carefully and make sure you have all the safety equipment you need.** If you feel uncomfortable working with acids, it might be a good idea to enlist the aid of someone such as a local high school chemistry teacher to help you.

### Safety

Acids can cause severe burns on skin, eyes, nose, and throat. Avoid inhalation, ingestion, and skin contact. Be familiar with the chemicals used in this procedure and use proper safety precautions. Obtain a copy of the *Material Safety Data Sheet* for all chemicals and make sure you read it and the container labels carefully.

Always wear safety goggles, laboratory apron, and chemical resistant gloves. Wear eye protection that will protect from splashes and impact. If any chemical gets in the eyes, wash

them continuously with flowing water and seek immediate medical attention.

Have safety shower, eyewash, fire extinguisher, telephone and emergency phone numbers handy.

Do not inhale fumes from chemicals. Perform all experiments under an exhaust hood or outside.

Do not eat, drink, or smoke while handling chemicals.

If any chemical comes in contact with the skin, wash it immediately and summon medical assistance. Refer to the *Material Safety Data Sheet* for more information.

Read the chemical container warning label before removing a chemical from its container.

Never work alone!

### Some Basic Facts About Gold

Gold is found in almost every piece of electronics manufactured today. It is used in semiconductor packages, connectors, printed circuits, telephones, relays, communications equipment, contacts, and switches to name only a few. Gold is used in electronics because of its properties. It has excellent conductivity, is resistant to corrosion and oxidation, and is very malleable. Gold can be fashioned into very small wires and thin sheets. An ounce of gold can be made into a sheet covering 250 square feet and only four-millionths of an inch thick or drawn into a wire 50 miles long.

Gold occurs in seawater in the amount of 0.1 to 2.0 milligrams (mg) per ton and the earth's crust is estimated to have an average gold content of about 0.0034 gram per metric ton.

Gold is measured in

"troy" weight. There are 31.1 grams of gold in a troy ounce. Since gold is usually alloyed with other metals, a measurement called the "karat" is used to express the amount of gold with 24 karat being pure gold. For example, 14 karat gold contains 14 parts gold and 10 parts other metals. Fineness refers to the weight proportion of pure gold in an alloy expressed in parts per thousand.

Gold resists attack by most chemicals including nitric acid, sulfuric acid, and hydrochloric acid. However, it can be dissolved in aqua regia. Aqua regia is a solution of one part concentrated nitric acid and three parts concentrated hydrochloric acid. It means "royal water."

### Sources of Gold

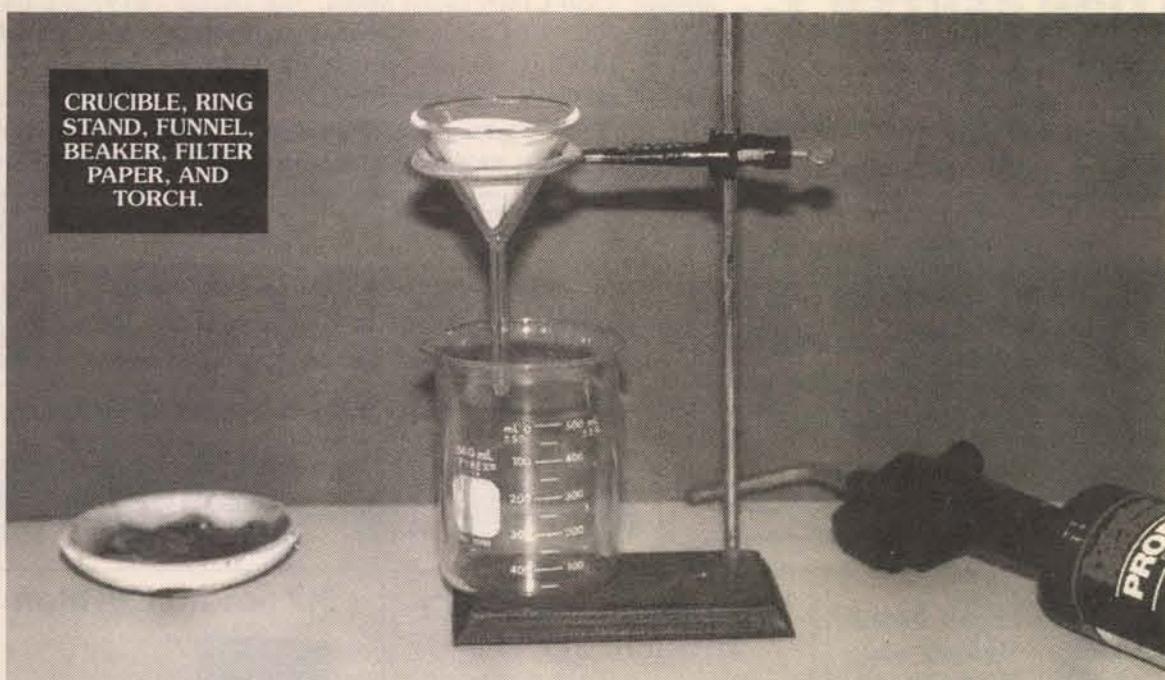
The first step is to obtain some gold containing components. This can be some old military connectors, circuit card edges, gold plated terminals, or contacts. Remember if it looks like gold then it's worth getting. Also, the older the electronics are, the thicker the gold is likely to be. This is because gold was cheaper then and the methods used to deposit gold were not as good as they are now. So older material is better, but it's not necessary.

Some moderately-sized operations

- A. Hydrochloric Acid HCl (reagent)
- B. Nitric Acid HNO<sub>3</sub> (reagent)
- C. Dibutyl Carbitol (diethylene glycol dibutyl ether)
- D. Potassium Oxalate K<sub>2</sub>C<sub>2</sub>O<sub>4</sub>
- E. Distilled Water
- F. Filter Paper
- G. One 500ml Beaker and One 600ml Beaker
- H. Glass Funnel
- I. Stainless Steel Forceps or Long Tweezers
- J. Crucible
- K. Propane Torch
- L. Ring Stand

Table I: Supplies and Equipment

CRUCIBLE, RING STAND, FUNNEL, BEAKER, FILTER PAPER, AND TORCH.



have grinders to grind up entire circuit boards and then process the grindings. Gold-plated components are recommended here to make it easy to see that the process is working.

Physically strip down the electronics and remove only the components that contain gold. In a connector, this means removing the gold-plated contacts; on a circuit card this means cutting off the edge connector. Reduce the components down to just the parts that have gold on them. For the purposes of this article, each piece should all be small enough to fit in a small laboratory beaker. To complete the process described below, you will need about enough gold-plated parts to fill a quart jar.

### Required Materials

Table I is a list of the chemicals and chemical supplies you will need. Note that this list does not include the safety equipment you need that was mentioned earlier. Some sources to obtain these supplies are listed in Table II. A local chemical supply company, as well as the chemical supply store at a nearby university, are good places to start. Also, the acids must be laboratory grade. Diluted acids will probably give poor results or not work at all.

### Procedure

Once you have all the supplies, chemicals, and some gold-bearing components ready, you can begin. It is important that you read the whole procedure as it is written here before you begin. Make sure you understand everything and that you have everything you need. Also make sure you are familiar with the section on safety. The following is the step-by-step procedure to remove the gold from the components that you collected earlier.

Prepare a solution by mixing 50ml of nitric acid with 150ml of hydrochloric acid in a 500ml beaker. This

Michael Young can be contacted at [myoung@mail.ala.net](mailto:myoung@mail.ala.net) or P.O. Box 145, Newville, AL 36353.

31.1 grams (g) = 1 troy ounce  
 $10^3$  grams (g) = 1 kilogram (kg)  
453.59 grams (g) = 1 pound (lb)  
1 milliliter (ml) = 1 cubic centimeter (cm<sup>3</sup>)  
1 milliliter (ml) =  $10^{-3}$  liters (l)  
Melting point of gold 1064.4° C or 1947° F  
Boiling point of gold 2857° C or 5174.6° F

liquid is yellow and produces poisonous, suffocating fumes. The solution of one part nitric acid and three parts hydrochloric acid is called aqua regia.

Use the stainless steel forceps to place some of the gold-bearing components in the solution. The gold will immediately begin to be stripped and dissolved. Observe the components carefully and remove them as soon as it appears that all the gold has been removed. Discard these and place some fresh components in the solution. Repeat this step until you run out of components or the aqua regia grows weak. You will know this because the reaction will slow and it will take longer to see the gold disappear.

Add about 100ml of distilled water to the solution from step 2 and stir gently. To this, add about 30ml of dibutyl carbitol and continue to stir gently. You should notice a brown extract forming in the beaker that will settle to the bottom. Allow the solution to sit until the brown extract settles to the bottom of the beaker. Carefully pour off the liquid into another beaker being careful to leave the extract behind in the first beaker.

To the beaker containing the brown extract, add distilled water in volume of about the same as the extract. Add about 2-3 grams of potassium oxalate and stir. It is desirable to stir this solution for a few hours, but good results can be had with less.

Remove the extract from the solution by pouring it into a glass funnel lined with filter paper. Make sure the solution is diluted with distilled water enough so that the acid does not melt the filter paper. Rinse with water until all of the extract is washed into the filter paper.

Place the filter paper in the crucible and allow to dry. Then take a

propane or oxygen/propane torch and gently heat the filter paper and extract. The filter paper will burn away. Continue to slowly heat the brown powder until it begins to vaporize. As the powder vaporizes you will see a small pellet of gold begin to form in the bottom of the crucible. Be careful not to over heat the gold causing it to boil away. Take care that the force of the torch flame doesn't blow the extract or the gold out of the crucible. Keep the torch on the lowest flame necessary.

### Summary

It is not unusual to obtain one or two grams of relatively pure gold on this scale. The gold obtained is typically of good purity with low concentrations of alloyed metals such as copper. Of course, more gold can be obtained per run by increasing the scale of this process.

Any number of variables can affect the outcome. One of these factors is temperature. You might want to experiment with warming the solution during the final stirring (step 4). Of course, the quality of the chemicals and the quality of the gold components will make a difference. While this particular process is useful for the hobbyist, there are several other processes that may be more appropriate for larger scale operations. These mainly vary in the method used to extract the gold from the aqua regia solution. This is a good area to experiment in and to do research.

Although the emphasis of this article is the recovery of gold from scrap electronics, the procedure for recovering gold from other sources such as jewelry, dental work, trophies, or eyeglass frames is essentially the same. Any gold-plated components can be used. NV

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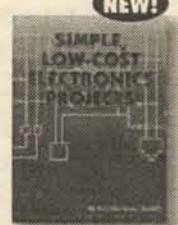
Table II: Sources of Supplies

Great Books for Hobbyists,  
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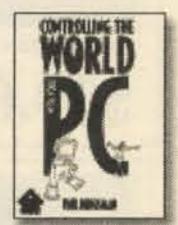
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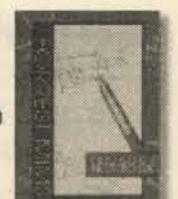


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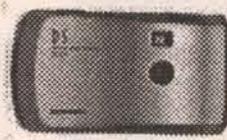
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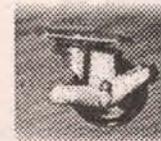
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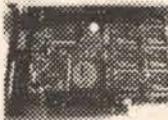
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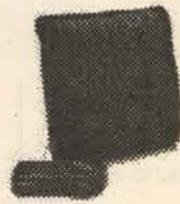
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# AMATEUR ROBOTICS

by Robert Nansel

Last time, I showed how to build a SIMMStick compatible with the Parallax BS-2. In the coming year, I intend to describe more projects using PBASIC controllers (such as the BS1-IC and the BS2-IC), but for the next few months, I want to shift into a different SIMMStick groove, one that will give at least a big price/performance boost over Stamps and offer much more flexibility.

There's a price to be paid for all these benefits, of course, and that price is learning to program in machine language — PIC assembly language in particular. The learning curve can be steep, but once you've done it, the results will more than justify the effort required.

In the process, I'll be showing you lots of tools, techniques, and resources that will ease the transition from PBASIC Stamps to assembly language Screamers. This month, I've also got tidbits on a better way to bend wire and where to look for technological inspiration.

## PICs, Stamps, and Ants

So far, all of the Breadbot projects I've presented in this column have used controllers programmed in either PBASIC I or PBASIC II. This has been convenient from the standpoint of just getting something up and running with a minimum of time, hassle, and cash. If you build more than one Breadbot, though, the cost of the PBASIC controllers, whether from Parallax or home-brewed with a SIMMStick, will mount up.

The BS2 SIMMStick from last time costs under \$40.00 US, not much cheaper than the Parallax BS2-IC (\$49.00 US). I could shave three, maybe four dollars off by soldering the chips in instead of using IC sockets, by using a ceramic resonator instead of a crystal, and by leaving out the voltage regulator (which isn't being used in Breadbot at present). If I were building just a couple Breadbots, I might well go this route if I wanted to stay with PBASIC as my programming environment.

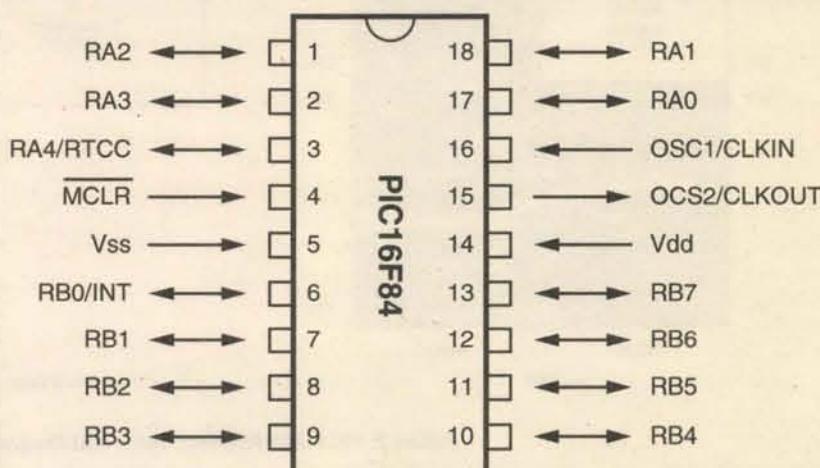
But what if I want to build a

# NOTEBOOK

dozen Breadbots, say for a robot ant colony? The cost of a dozen BS-2 SIMMStick brains alone would be about \$430.00 US, and it's likely that all the extra sensors and inter-ant communications needed would

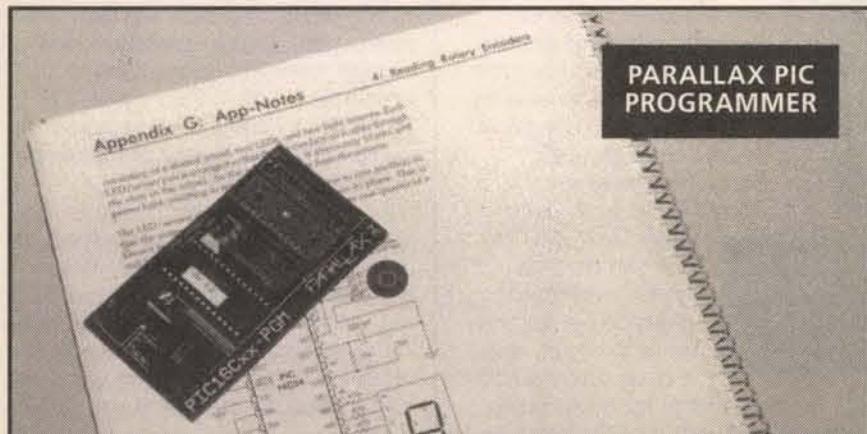
make the BS2 choke. At this point, I have to ask myself if there is a better way.

The most expensive part of the BS2 SIMMStick is Parallax's PBASIC II chip, which is really just a PIC16C57



Pin	Function
Vdd	Power supply 4.0 - 6.0 volts
Vss	Ground
RA0 - RA4	I/O Port A
RB0 - RB7	I/O Port B
INT	External interrupt input
RTCC	Real-time clock/counter input
MCLR	Master clear (reset)
OSC1/CLKIN	Oscillator input
OSC2/CLKOUT	Oscillator output (OSC/4)

Figure 1: PIC16F84 pin-out

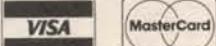


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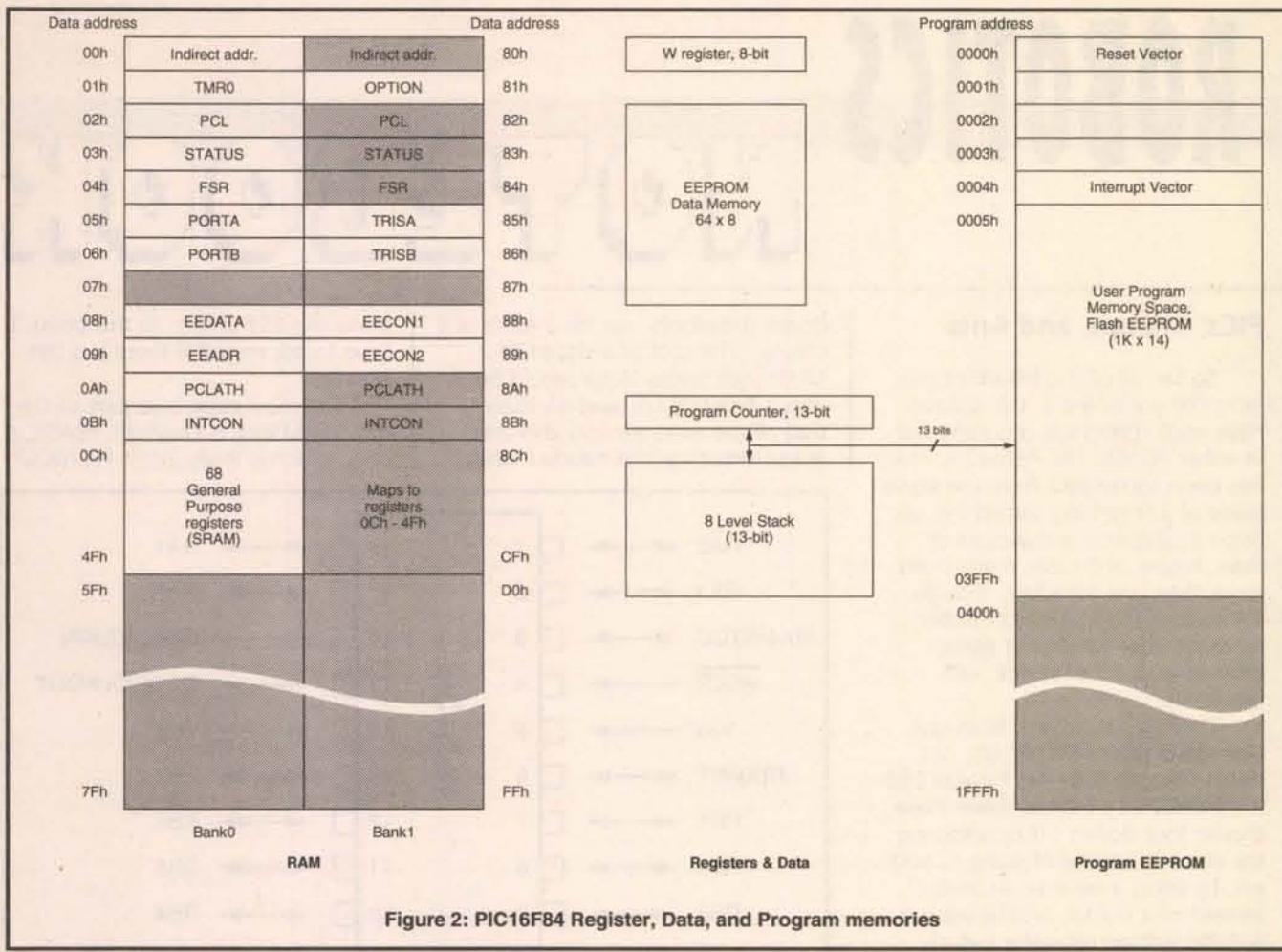
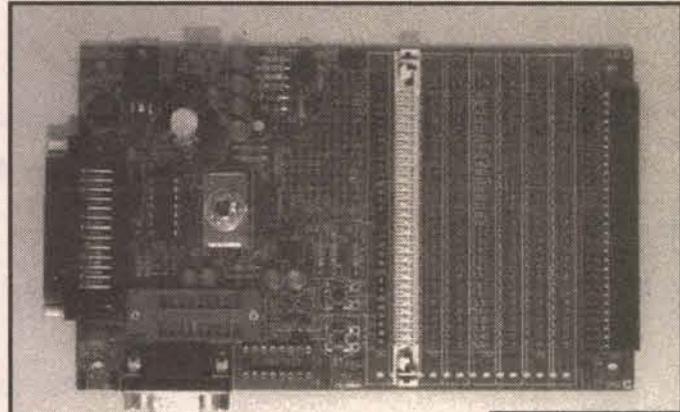


Figure 2: PIC16F84 Register, Data, and Program memories

programmed with Parallax's proprietary firmware.

The PIC16C57 currently cost less than \$6.00 US in a quantity of one for the "OTP" version, less than a quarter the price of the PBASIC II chip; if I could use a plain vanilla PIC, the cost of each Breadbot controller would be cut in half.

The problem with this rosy picture, though, is "OTP." That stands for one-time-programmable; great for production, but not for experimentation. There is a UV-erasable EPROM version of the PIC16C57, but it costs \$11.00 US. This is still cheaper than the PBASIC II, but I don't want to deal with the hassle of UV erasure. In-circuit reprogrammability is one of the big advantages of the BASIC



Stamps, and I'm loathe to let it go.

Luckily, Microchip has an EEPROM PIC available, the PIC16F84.

### Flash to the Rescue

The PIC16F84 is a member of

Microchip's family of 14-bit core microcontrollers (the PIC16C57 is part of their older 12-bit family). It comes in a plastic package with 18 pins, of which 13 are I/O lines. It has 68 eight-bit words of directly addressed general-purpose R/W data memory and 64 eight-bit words of indirectly addressed data EEPROM. The program is stored in 1K by 14-bit

Flash EEPROM. The F84 can thus be erased and reprogrammed in seconds while in-circuit, and it costs under \$7.00

US, making it ideal for robot prototype development (see Figures 1 and 2).

The 14-bit core PICs can't all compete with a Motorola 68HC11 in

terms of on-chip RAM and EPROM, and they have no expansion bus so you can't add more RAM or ROM externally. They excel, though, where you need something small and fast, just enough computing horsepower to do the job. And cheap.

Even a low-end chip like the 68HC11A1 costs twice as much as a PIC16F84 and, unlike the Motorola chip, when you are satisfied with your code on an F84, you can easily port it to another 14-bit core PIC, such as the PIC16C711. The PIC16C711 comes in a pin-compatible OTP package functionally identical to the F84, only it has four optional A/D inputs, and it's two times faster and costs a couple dollars less than the F84.

For simple applications, you could even go all the way down to one of the eight-pin PICs now available, such as the PIC12C671 and PIC12C672, both under \$4.00 US. Motorola has nothing even close to these.

Still, some of you may be more familiar and comfortable with the HC11's instruction set and architecture, and the first time you look the PIC over it may seem alien and primitive. Some years ago when I first read the PIC databooks, I had that same impression, but they have grown on me. Let me tell you why.

### Tour de PIC

Since the PIC doesn't have all the fancy built-in addressing modes of the 68HC11 (which has over 300 instructions), some operations will require more PIC instructions to accomplish – but, then again, the PIC16F84 has only 35 instructions to begin with, so it's easy to memorize them all (see Table 1).

The F84 has most of the binary arithmetic instructions you expect in an eight-bit microcontroller, including adding, subtracting, incrementing, decrementing, and bit-wise logical operations. It doesn't have BCD math instructions, so those will have to be faked in software if you need them.

Of special interest to control freaks (that's you, the Amateur Robot Builder, bubba), the PIC has a

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R/W-0	R/W-0	R/W-0	R-1	R-1	R/W-x	R/W-x	R/W-x
IRP	RP1	RP0	TO	PD	Z	DC	C

bit 7

R = Readable bit

W = Writable bit

- n = Value at Power On Reset (POR)

**Bit 0:** C: Carry/Borrow bit

1 = Carry from msb of result occurred

0 = No carry from msb of result occurred

For subtraction, C behaves like a Positive flag that is set when the result is not less than zero, and cleared when the result is negative. For rotate instructions, C is loaded with either the high order bit (for RLF) or the low order bit (for RRF) of the source register.

**Bit 1:** DC: Digit Carry/Borrow bit

1 = Carry from bit 3 of result occurred

0 = No carry from bit 3 of result occurred

DC indicates when more than one 4-bit hex digit was necessary to accommodate the result. For subtract operations DC behaves in the same manner as C, except it operates only on the least significant nibble.

**Bit 2:** Z: Zero bit

1 = The result of an arithmetic or logic operation is zero

0 = The result of an arithmetic or logic operation is not zero

**Bit 3:** PD: Power-down bit

1 = After power-up or CLRWDI instruction

0 = After SLEEP instruction

**Bit 4:** TO: Time-out bit

1 = After power-up, CLRWDI instruction, or SLEEP instruction

0 = A Watch Dog Timer time-out occurred

**Bit 5-6:** RP0, RP1: Register Bank Select bits for direct addressing

00 = Bank 0: 00h - 7Fh

01 = Bank 1: 80h - FFh

10 = Bank 2: 100h - 17Fh (unimplemented on PIC16F84)

11 = Bank 3: 180h - 1FFh (unimplemented on PIC16F84)

Each bank is 128 bytes. Only RP0 is used by PIC16F84; RP1 should remain clear.

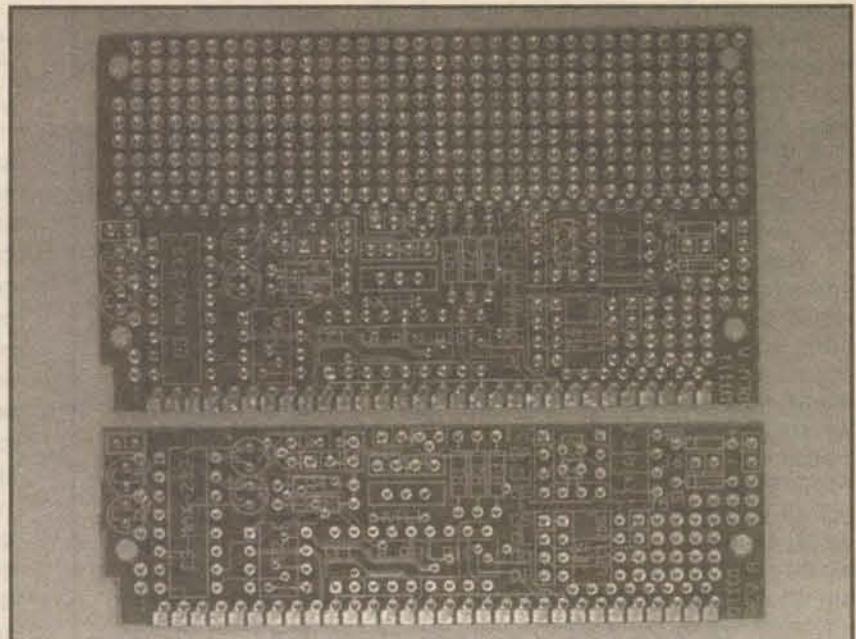
**Bit 7:** IRP: Register Bank Select bit for indirect addressing

0 = Bank 0, 1: 00h - FFh

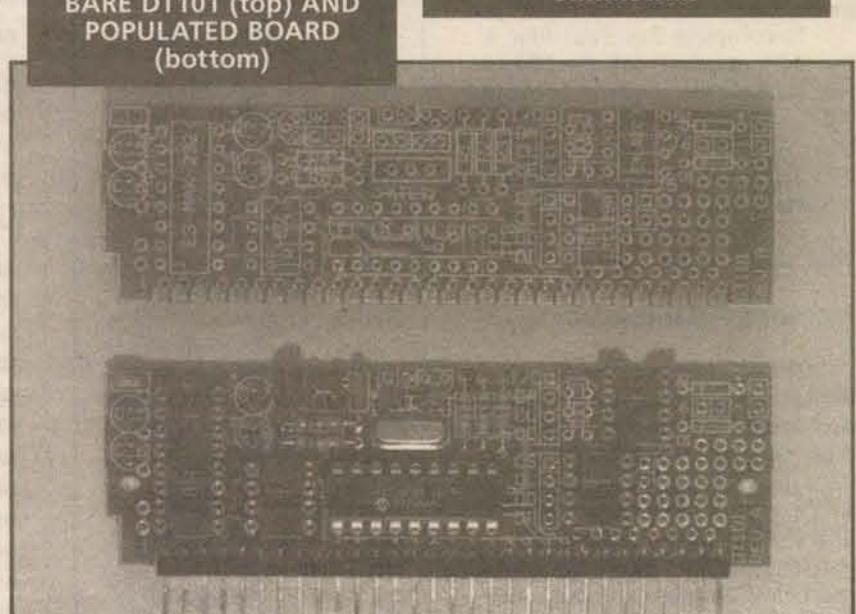
1 = Bank 2, 3: 100h - 1FFh

IRP bit is not used by PIC16F84, and should remain clear.

Figure 3: File Status Register (FSR) Flags



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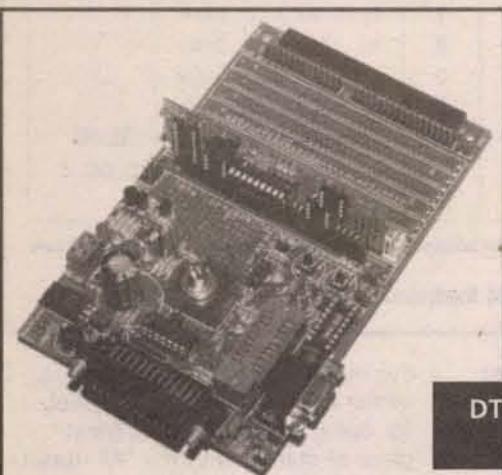
ing of any individual writable bit in RAM without the need for sequences of ANDing or ORing an entire byte with a bit mask to isolate the one bit you are after. BSF and BCF are paired up with BTFSS and BTFSC, the bit test and skip instructions (more on these in a moment).

The PIC's branching instructions take a little getting used to. While the PIC

does have ordinary unconditional GOTO, CALL, and RETURN-type instructions, it has no true conditional branching instructions. Instead, it has conditional skipping instructions, that is, instructions that skip over the instruction immediately following them when their conditional is satisfied. DECFSZ, for instance, skips the next instruction if, after decrementing a file register, the result is zero. INCFSZ works the same way, except the file register is incremented. Two other skip instructions, BTFSC (bit test f, skip if clear) and BTFSS (bit test f, skip if set) do

similar jobs, but their conditionals can be any bit in RAM, including bits in the STATUS register.

But to get true conditional branches, it does take two PIC instructions. Place an unconditional GOTO after any of the four skip-type instructions, and when the skip condition is true, the GOTO instruction is skipped and execution resumes with the instruction following the GOTO. Likewise, combining a skip with CALL or RETURN gives you con-



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couple instructions — BSF and BCF — which allow direct setting or clear-

ing of any individual writable bit in RAM without the need for sequences of ANDing or ORing an entire byte with a bit mask to isolate the one bit you are after. BSF and BCF are paired up with BTFSS and BTFSC, the bit test and skip instructions (more on these in a moment).

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ditional subroutine calls and returns.

Having to use two instructions to perform what most other processors do with one may seem to be a drag, but you get much more flexibility overall. Because they require two instructions to implement, conditional branches take up two program words, or 28 bits.

The nearest equivalent single-instruction branch in a 68HC11 would take up just 16 bits, or two bytes, one byte for the branch opcode and one byte for the relative branch address. But note that eight-bit relative branches only allow branches in the range from -128 to +127. For an HC11 conditional branch to access its entire memory range, as the PIC's skip/goto combination can, you need to combine a branch with the unconditional jump, a total of five bytes, or 40 bits. The PIC comes out the clear winner. For the same functionality, the PIC model takes up less chip real estate.

To complete this short tour of the PIC instruction set, the F84 has two housekeeping instructions, CLR-WDT which is the only instruction that can clear the Watch Dog Timer, and SLEEP, which puts the F84 into a lower-power standby mode.

That's it. Thirty-five instructions. That wasn't so bad, was it?

## Harvard Architecture

The PIC family of microcontrollers are all examples of Harvard Architecture computers. This means they have separate program and data memory busses instead of the single memory bus used in traditional Von Neumann architecture machines. In Von Neumann machines, program and data are fetched over the same bus, and this makes the shared bus a bottleneck.

Having separate busses not only eliminates the bottleneck, it greatly simplifies the circuitry of the MPU and increases memory efficiency since the sizes of instruction and data words need not be the same. It also allows the MPU to simultaneously access both program instructions and data. This, combined with

efficient pipelining explains why PICs are so fast.

A PIC16F84 operating with a 10-MHz crystal has a 400 ns instruction cycle time, and all instructions execute in a single cycle, except instructions which change the program execution flow (i.e., branches, subroutine calls, and returns; these take two cycles).

Interrupt latency — the time it takes the PIC to respond to an interrupt — is very short, just three to four processor cycles, independent of the instruction being interrupted. For a 10-MHz system, this corresponds to a delay of 1.2 to 1.6 microseconds before interrupt processing begins. In contrast, a Motorola 68HC11 running at 8 MHz can take anywhere from two to 41 processor cycles — one to 20.5 microseconds — to begin processing an interrupt, which can introduce unacceptable jitter in some systems.

Another wrinkle of the PIC's Harvard architecture is that separate program and data memory spaces make it impossible for a PIC program to erroneously execute data. Neither can instructions in the program space accidentally be corrupted by data overwrites. This increases the resistance of the controller to electrical upsets common in control systems and makes for a more reliable system.

## PIC Development Tools

Okay, assuming you're now at least interested in using PICs in robots, how do you program them?

Mnemonic, Operands	Description		Cycles	14-bit Opcode MSB	Flags Affected
<b>BYTE-ORIENTED FILE REGISTER OPERATIONS</b>					
<b>ADDWF</b> f,d	Add W and f		1	00 0111 dfff ffff	C, DC, Z
<b>ANDWF</b> f,d	AND W with f		1	00 0101 dfff ffff	Z
<b>CLRF</b> f	Clear f		1	00 0001 1fff ffff	Z
<b>CLRW</b> —	Clear W		1	00 0001 0000 0011	Z
<b>COMF</b> f,d	Complement f		1	00 1001 dfff ffff	Z
<b>DECFSZ</b> f,d	Decrement f, Skip if 0		1(2)	00 1011 dfff ffff	Z
<b>INCF</b> f,d	Increment f		1	00 1010 dfff ffff	Z
<b>INCFSZ</b> f,d	Increment f, Skip if 0		1(2)	00 1111 dfff ffff	Z
<b>IORWF</b> f,d	Inclusive OR W with f		1	00 0100 dfff ffff	Z
<b>MOVF</b> f,d	Move f		1	00 1000 dfff ffff	Z
<b>MOVWF</b> f	Move W to f		1	00 0000 1fff ffff	
<b>NOP</b> —	No Operation		1	00 0000 0000 0000	
<b>RLF</b> f,d	Rotate f Left through Carry		1	00 1101 dfff ffff	C
<b>RRF</b> f,d	Rotate f Right through Carry		1	00 1100 dfff ffff	C
<b>SUBWF</b> f,d	Subtract W from f		1	00 0010 dfff ffff	C, DC, Z
<b>SWAPF</b> f,d	Swap nybbles in f		1	00 1110 dfff ffff	
<b>XORWF</b> f,d	Exclusive OR W with f		1	00 0110 dfff ffff	Z
<b>BIT-ORIENTED FILE REGISTER OPERATIONS</b>					
<b>BCF</b> f,b	Bit Clear f		1	01 00bb bfff ffff	
<b>BSF</b> f,b	Bit Set f		1	01 01bb bfff ffff	
<b>BTFSZ</b> f,b	Bit Test f, Skip if Clear		1(2)	01 10bb bfff ffff	
<b>BTFSZ</b> f,b	Bit Test f, Skip if Set		1(2)	01 11bb bfff ffff	
<b>LITERAL AND CONTROL OPERATIONS</b>					
<b>ADDLW</b> k	Add literal to W		1	11 111x kkkk kkkk	C, DC, Z
<b>ANDLW</b> k	AND literal with W		1	11 1001 kkkk kkkk	Z
<b>CALL</b> k	Call subroutine		2	10 0kkk kkkk kkkk	TO, PD
<b>CLRWD</b> —	Clear Watchdog Timer		1	00 0000 0110 0100	
<b>GOTO</b> k	Go to address		2	10 1kkk kkkk kkkk	
<b>IORLW</b> k	Inclusive OR literal with W		1	11 1000 kkkk kkkk	
<b>MOVLW</b> k	Move literal to W		1	11 00xx kkkk kkkk	
<b>RETIE</b> —	Return From Interrupt		2	00 0000 0000 1001	
<b>RETLW</b> k	Return with literal in W		2	11 01xx kkkk kkkk	
<b>RETURN</b> —	Return from Subroutine		2	00 0000 0000 1000	
<b>SLEEP</b> —	Go into standby mode		1	00 0000 0110 0011	TO, PD
<b>SUBLW</b> k	Subtract W from literal		1	11 110x kkkk kkkk	C, DC, Z
<b>XORLW</b> k	Exclusive OR literal with W		1	11 1010 kkkk kkkk	Z

f = file address

d = dest: 0 for W, 1 for f

b = bit address

k = literal constant

x = don't care

Table 1: PIC16F84 Instruction Set

A quick search on the Web will get you hundreds of links, and you could spend months following all the interesting ones. To save you some time,

I've included a sidebar with my list of the best of what's on the Web for doing things PICish. A great place to start is with the "All About

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PIC" website. If this site doesn't point you to what you need, I don't know what will.

You'll be astonished at the sheer mass of PIC development software and hardware tools out there, from the expensive commercial development tool suites to the anarchic, homebrew, by-gosh-it-actually-works gear. Most of the latter is freeware or shareware, much of it surprisingly good.

First, you'll need an assembler of some kind. For Wintel users, one place to start is with the Mothership itself: the Microchip website. They have available for download a good macro assembler — MPASM — and a serviceable simulator — MPSIM. They also will gladly point you to higher-end tools such as emulators and optimizing C compilers.

For Macintosh users, there are several excellent software packages available. I've been using the Crossbow cross-assembler package for many years, long enough ago that I actually paid for it. I would kick myself now that it's available as freeware from Peripheral Issues, but it's an even better product covering more processors now than when it was commercial. It's an integrated editor, macro assembler, and downloader, and it assembles code for every common eight-bit processor out there (and a few uncommon ones, too).

I've also used MacPIC by Kevin Coble. It's shareware with a integrated editor, assembler, simulator/debugger, and downloader. Topnotch.

Next, you'll need some hardware to actually program the PICs. The sheer number of choices here will surely boggle your mind. Most programmers require a PC with a parallel port to operate, though a few use a serial interface (which Mac and Linux users will appreciate). No matter what your budget or performance needs, I guarantee you'll be able to find a programmer that will suit you.

Despite being a devoted Mac user, I don't yet own a serial port PIC programmer. I do, however, own and use two different parallel port programmers, the DonTronics DT001 and the Parallax PIC16Cxx-PGM (see photos). I use these with my toy computer, an embarrassing 386 DOS machine I keep in my basement so folks won't see it.

The DT001 can be configured to program individual chips, to program SIMMStick boards in-circuit, or to function as a SIMMStick motherboard, complete with expansion connectors and RS-232 communications. It's available as a bare PC board directly from DonTronics in Australia or from any of the numerous SIMMStick distributors world-wide. I've purchased boards and parts from both Don at DonTronics and Ben Wirz at Wirz Electronics; they're good people, with fast and courteous service.

The DT001 is well-documented and inexpensive to build. Recommended.

The Parallax PIC16Cxx-PGM costs a bit more than the DT001, but it comes already built and can handle a wider range of PIC chips, including the older 12-bit core family, which use a different programming method than Microchip's newer PICs. It's available in a "Hobbyist Pack" for \$109.00 US from Digi-Key ([www.digikey.com](http://www.digikey.com)).

With the Hobbyist Pack, you'll have to supply your own wall-wart power transformer, build the inter-

face cable, and print out the documentation yourself. This will cost you about \$10.00 and half an hour of your time, but when you are finished you'll have saved yourself over \$100.00.

Once you have an assembler, a programmer, and the software to run it, then you need a way to build the PIC into a circuit. There are scads of PIC breadboards out there. I have two favorites: the line of PICProto boards from microEngineering Labs and, of course, SIMMSticks.

## More Options, More Options!

Among his many SIMMStick products, Don McKenzie of DonTronics fame has two great boards available — the DT101 and the newer DT111 — designed especially for 18-pin PICs such as the 16F84. The only difference between the two is the DT111 is a double-height SIMMStick with a nice proto-

## PIC and SIMMStick Internet Resources:

the Macintosh)

**RS-232 Serial PIC programmer project**,  
by Jens Madsen  
[www.gbar.dtu.dk/~c88600/newpic.htm](http://www.gbar.dtu.dk/~c88600/newpic.htm)

### Scenix Semiconductor

3160 De La Cruz Blvd. Suite 200  
Santa Clara, CA 95054  
Tel: 408-327-8888  
Fax: 408-327-8880  
[www.scenix.com](http://www.scenix.com)

(SX18/20AC100 MCU chips, backward-compatible with PIC 16C5x)

### Scott Edwards Electronics, Inc.

P.O. Box 160  
Sierra Vista AZ 85636  
Tel: 520-459-4802  
Fax: 520-459-0623  
[www.seetron.com](http://www.seetron.com)

(Counterfeit Stamp, SSC Serial Servo Controller, Serial LCD)

### SIGNUM Systems

Thousand Oaks, CA  
Tel: 1-800-838-8012  
Fax: 805-371-4610  
[www.signum.com](http://www.signum.com)

(ICEPIC in-circuit emulator)

### Sirius microSystems

172 Harvard Road  
Waterloo  
Ontario, Canada N2J 3V3  
Tel: 519-886-4462  
Fax: 519-886-4253  
[www.siriusmicro.com](http://www.siriusmicro.com)

(PIC development boards, programmers, assembler)

### Square 1 Electronics

P.O. Box 501  
Kelseyville, CA 95451  
Tel: 707-279-8881  
Fax: 707-279-8883  
[www.sq-1.com](http://www.sq-1.com)

("Easy PIC'n" & "PIC'n Up The Pace" books)

### TechTools

P.O. Box 462101  
Garland, TX 75046  
Tel: 972-272-9392  
Fax: 972-494-5814  
[www.tech-tools.com](http://www.tech-tools.com)

(PICmicro in-circuit emulator, assembler)

### Wirz Electronics SIMMSticks

P.O. Box 457  
Littleton, MA 01460-0457  
Tel: 1-888-289-9479  
Fax: 978-448-0196  
[www.wirz.com](http://www.wirz.com)

(SIMMSticks, SLI serial LCD interface, kits)

### PICLIST List Server

The PICLIST is one of the most helpful resources for PICs on the Internet. To subscribe to the PICLIST, send an E-Mail to: [listserv@mitvma.mit.edu](mailto:listserv@mitvma.mit.edu) with a blank subject line, and a body of SUB PICLIST. Be warned: there are thousands of people on this list, and it generates 200+ messages a day.

#### Advanced Transdata Corp.

14330 Midway Rd.  
Suite 128  
Dallas, TX 75244  
Tel: 972-980-2960  
Fax: 972-980-2937  
[www.adv-transdata.com](http://www.adv-transdata.com)  
(RICE17A in-circuit emulator, PGM16N and PGM2000 programmers)

**"All About PIC"** website  
[www.ormix.riga.lv/eng/mchip/mchip.htm](http://www.ormix.riga.lv/eng/mchip/mchip.htm)  
(Incredible number of links to PIC resources)

**Byte Craft Ltd.**  
421 King Street  
North Waterloo  
Ontario, Canada N2K 4E4  
Tel: 519-888-6911  
Fax: 519-746-6751  
[www.bytecraft.com](http://www.bytecraft.com)

**CCS**  
P.O. Box 2542  
Brookfield, WI 53008  
Tel: 414-781-2794 x30  
Fax: 414-781-3241  
[www.ccsinfo.com/picc.html](http://www.ccsinfo.com/picc.html)  
(PIC C compilers for DOS and Windows)

**COMFILE Technology**  
Seoul, Korea  
Tel: 82-2-711-2592  
Fax: 82-2-711-2593  
[www.comfile.co.kr](http://www.comfile.co.kr)  
(PIC12/14/16 Emulator/programmer)

**Dallas Semiconductor**  
4401 South Beltwood Parkway  
Dallas, TX 75244-3292  
Tel: 972-371-4448  
Fax: 972-371-3715  
[www.dalsemi.com](http://www.dalsemi.com)  
(Serial RTCs, temp. sensors, batt. monitors)

**DonTronics**  
P.O. Box 595  
Tullamarine 3043  
Australia  
Tel: +61 3 9338-6286  
Fax: +61 3 9338-2935  
[www.dontronics.com](http://www.dontronics.com)  
(SIMMStick PC boards, development systems, and software)

**HI-TECH Software LLC**  
7830 Ellis Road  
Suite 105  
Melbourne, FL 32904  
Tel: 1-800-735-5715  
Fax: 407-722-2902  
(HI-TECH PIC C compiler for the PIC16Cxx)

**HI-TECH Software**  
P.O. Box 103  
Alderley, QLD 4051  
AUSTRALIA  
Tel: +61 7 3354 2411  
Fax: +61 7 3354 2422  
(HI-TECH PIC C compiler for the PIC16Cxx)

**ITU Technologies**  
3704 Cheviot Ave. Suite 3  
Cincinnati, OH 45211

Tel: 1-888-448-8832, 513-661-7523  
Fax: 513-661-7534  
[www.itutech.com](http://www.itutech.com)

(PIC development systems, programmers, compilers)

**Linear Technology Corporation**  
1630 McCarthy Blvd.  
Milpitas, CA 95035-7417  
Tel: 1-800-454-6327, 408-432-1900  
Fax: 408-434-0507  
[www.linear-tech.com](http://www.linear-tech.com)  
(Serial A/D & D/A convertors)

**Linux RS-232 PIC programmer**  
by Jaakko Hyvatti  
[www.iki.fi/hyvatti/pic/picprog.html](http://www.iki.fi/hyvatti/pic/picprog.html)

**MacPIC**, by Kevin Coble  
[ftp://ftp.srv.net/pub/users/kxc/](http://ftp.srv.net/pub/users/kxc/)  
(Macintosh shareware: integrated editor, assembler, simulator/debugger, and programmer for PIC microcontroller)

**Microchip Technology, Inc.**  
Tel: 1-888-628-6247, 602-786-7200  
Fax: 602-899-9210  
[www.microchip.com](http://www.microchip.com)  
(PIC chips, PICSTART development systems, MPASM assembler, MPSIM simulator, serial EEPROMs)

**microEngineering Labs, Inc.**  
Box 7532  
Colorado Springs, CO 80933  
Tel: 719-520-5323  
Fax: 719-520-1867  
[www.melabs.com](http://www.melabs.com)  
(PIC prototyping boards, EPIC programmer, PicBasic Pro Compiler)

**Micro Mint**  
4 Park St.  
Vernon, CT 06066  
Tel: 1-800-635-3355, 860-871-6170  
Fax: 860-872-2204  
[www.micromint.com](http://www.micromint.com)  
(PicSticks & BASIC compiler)

**Myke Predko**  
[www.myke.com](http://www.myke.com)  
(author of *Programming and Customizing the PIC Microcontroller*)

**National Semiconductor Corp.**  
2900 Semiconductor Drive  
Santa Clara, CA 95052-8090  
Tel: 1-800-272-9959  
TWX: 910-339-9240  
[www.national.com](http://www.national.com)  
(Serial A/D & D/A convertors)

**Parallax, Inc.**  
3805 Atherton Road, Ste. 102  
Rocklin, CA 95765  
Tel: 1-800-512-1024, 916-624-8333  
[www.parallaxinc.com](http://www.parallaxinc.com)  
(PIC16Cxx-PGM programmer, SX-Key debugger/programmer, BASIC Stamps)

**Peripheral Issues**  
P.O. Box 543  
Mashpee, MA 02649  
Tel: 508-563-7190  
Fax: 508-563-7191  
[www.periph.com/crossbowweb/Crossbow.html](http://www.periph.com/crossbowweb/Crossbow.html)  
(Freeware Crossbow cross assembler for

## More Options, More Options!

Among his many SIMMStick products, Don McKenzie of DonTronics fame has two great boards available — the DT101 and the newer DT111 — designed especially for 18-pin PICs such as the 16F84. The only difference between the two is the DT111 is a double-height SIMMStick with a nice proto-

typing area added above the single-height DT101 layout. Both are high-quality boards with component placement silkscreen, solder mask, and heavy power and ground trace layout.

In the minimal configuration (see photo), these boards need only an F84 and either two 15 pF capacitors and a crystal or a three-pin ceramic resonator.

But there are many more options — "More options, more options!" seems to be Don's rallying cry — so you can choose according to your needs. There are four pre-wired options (all you have to do is solder the necessary components in place) and two more options requiring a few wire jumpers each to connect them to the rest of the circuit.

The first pre-wired option (PWO) you can add is a simple on-card voltage regulator. Don has thoughtfully provided pads on the regulator output where you can install a two-pin header; cut the trace between the pads, and then you can use a shorting jumper to isolate the output of the regulator circuit as needed.

This is necessary if you want to program the SIMMStick in-circuit on the DT001 programmer. The DT001 switches pin 7 of the SIMMStick bus (SS-Bus) between +5V and the programming voltage Vpp and, if you have an on-card regulator installed on the SIMMStick, you must temporarily isolate its output so it doesn't fight the programmer voltage.

The second PWO is to add two reset resistors and a pullup for the PIC's RTCC pin (pin 14, "IO," on the SS-Bus). You can also install a TO-92 package brown-out reset IC to put the F84 into reset when the power supply goes squirrelly and voltage drops. I recommend installing the brown-out IC — robot power supplies are heinously noisy.

The third PWO is an eight-pin 24LCxx-type serial EEPROM. These I2C devices range in capacity from 1 to 64 Kbits and can be used for storing auxiliary data or tokens to be interpreted by a virtual machine programmed into the PIC.

This is the way the BS2 SIMMStick works, and Dunfield Development Systems ([www.dunfield.com/catalog.html#cflea](http://www.dunfield.com/catalog.html#cflea)) has

CFLEA, an interpreted C that can use the same token storage approach.

The fourth PWO is an RS-232 serial level translator. Just add a MAX-232 chip and four 1 uF capacitors, and you get a standard RS-232 interface. Not as funky as the two-transistor method BASIC Stamps use, but it's reliable and full-duplex.

Finally, Don has provided two partially-wired options. The first is a place to put an eight-pin SPI or Microwire-type serial interface ADC or DAC. The second is a place to put an eight-pin, serial interface real-time clock/calendar chip, along with its 32.768 KHz crystal, and steering diodes for an optional 3V coin cell for battery backup.

### Squashing the Learning Curve

If my rants above and the Web resources in the sidebar aren't enough for you to get going with PICs, then you'll need to hit the books. The bible for all PIC microcontrollers is Microchip's own *PIC16/17 Microcontroller Databook*. The writing is often turgid and the order of presentation sometimes confusing, but this book is the authority of last resort. The answer is in there — if you can find it and decipher it.

Fortunately, there are third-party books around to help you scale the steep learning curve. For those new to assembly language in general and to PICs in particular, I would recommend *Easy PIC'n* and the follow-up *PIC'n up the Pace* from Square 1 Electronics. These books will take you by the hand and very gently initiate you into the mysteries of PIC programming.

If you've already learned to program a few other microcontrollers, or if you just want something more assertive and meaty than the *PIC'n* books, then you might find *Programming and Customizing the PIC Microcontroller* (McGraw-Hill 1998, ISBN 0-07-913646-X) by Myke Predko more to your taste. It's my first choice, hands down.

And, if all this PIC stuff is making your head throb and kindling a desire to break things, I have just the gadget for you.

### Mini Wire Bender

In my very first "Amateur Robotics Notebook" column (June '98), I described how to improvise a wire-bending jig from a hunk of wood and a couple wood screws. It works, but it takes some practice to get good bends. In a hobby shop, I came across a much easier way to bend music wire a couple months after I wrote that first column: the K&S Engineering Mini Wire Bender. This little beauty allows you to make accurate bends in solid brass or steel wire up to 1/8" diameter.

It's a two-piece unit, a steel base with a pivot pin and a clamping screw, and a torque handle that fits over the pivot pin. First you securely clamp the base in the jaws of a bench vise, then place the wire to be bent diagonally between the pivot pin and the clamping screw. Next, tighten the clamping screw to hold the wire in place, and fit the torque handle over the pivot pin. A short steel pin protrudes downward from the torque handle and engages the wire so that when you pull the handle back, the wire bends around the pivot pin. It produces a perfect radius and the wire doesn't even get nicked. Cost? Just \$10.00 US.

You should be able to find one of these in any well-stocked hobby shop. If you can't find one, try contacting the company directly:

**K&S Engineering**  
6917 West 59th Street  
Chicago, IL 60638  
Tel: 773-586-8503  
Fax: 773-586-8556

### Forgotten Technologies

Robot builders — or thing-makers of any kind, for that matter — are always on the lookout for information about new techniques and tools to build oddball devices. Sometimes just knowing that a certain tool exists can inspire solutions to problems that seem unsolvable at first.

Sometimes the tools and techniques don't even have to be new to be of help. In fact, sometimes the older and more obscure the stuff is, the more readily it can be adapted.

and used by the amateur. These "forgotten" technologies use old tools and methods that are often cheaper and more easily understood than modern processes.

I spend a lot of time browsing books, magazines, and websites looking for these little kernels of forgotten tech. This month, I came across a treasure trove: John Strong's 1938 *Procedures in Experimental Physics*. It was out of print until 1986 when Lindsay Publications reprinted it under their "Lost Technology" series (ISBN 0-917914-56-2). At \$25.95 US, it's a bargain.

In Strong's book, you'll find detailed drawings and hands-on descriptions of doing laboratory glass-blowing, working with high vacuum, making optical instruments, Geiger tubes, photometers, electrometers, and many other devices, exotic and mundane. The book is old enough that many of these techniques aren't taught anymore, not because they aren't useful, but because they can't be as readily automated or are too expensive for mass production. But for one-off work, they can be ideal. Browse through this book and dream of what you could make.

Lindsay Publications specializes in books that encourage not only dreaming but doing. Just reading their catalog alone is inspirational. Check out their website at [www.lindsaybooks.com](http://www.lindsaybooks.com). Order their catalogs. You won't be disappointed.

### Enough, Already!

That's all my space. Next time, I'll give Breadbot its fourth brain transplant, program the new brain, and add some spiffy wheel rotation sensors. NV

As always, if you have suggestions for improving Breadbot, if you've built a Breadbot, or if you have questions or comments about amateur robotics topics, you can reach me at:

**Robert Nansel**  
69 S. Fremont Ave. #2  
Pittsburgh, PA 15202

E-Mail: [bnansel@nauticom.net](mailto:bnansel@nauticom.net)

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Regal w/Remote	\$38	\$35	\$30
BC4535 86 Channel	\$30	\$28	\$25
Oak Sigma 99 Channel	\$45	\$40	\$35
75 Channel Converter	\$18	\$18	\$18
Zenith ST1600 w/Remote	\$75	\$70	\$65

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# New Product News

Continued from page 4

## EDE702 SERIAL LCD INTERFACE IC

E-Lab Digital Engineering, Inc. announces the release of their new EDE702 Serial LCD Interface IC.

This IC has been especially designed for cost-sensitive OEM applications, allowing nearly any text-based liquid crystal display screen to be controlled via a one-wire serial link - ideal for embedded microcontroller applications where minimal I/O pin usage is desired.

The EDE702 allows full LCD control, including the creation of custom characters, scrolling text, cursor on/off, etc.

With 2400/9600 baud rate and selectable data polarity, the EDE702 can interface to nearly any microcontroller capable of sending asynchronous serial data, and connection can be made without any type of voltage level conversion hardware.

The EDE702 allows circuit designers to easily add a LCD screen to their design



without the increased software overhead or I/O requirements accompanying the usual 11-pin LCD interface.

A serially-controlled digital output pin on the EDE702 makes its one-pin serially interface effectively a zero-pin interface! Eighteen pin DIP or SOIC packages are available; 1K pricing is \$4.50

For more information, contact:

**E-LAB DIGITAL ENGINEERING, INC.**  
1600 N. 291 HWY. STE. 339 DEPT. NV  
INDEPENDENCE, MO 64056  
816-257-9954 FAX: 816-257-9945  
WEB: <http://www.elabinc.com>  
E-MAIL: [support@elabinc.com](mailto:support@elabinc.com)



## SBC-1 EMBEDDED CONTROLLER

Industrologic is now shipping its SBC-1 embedded controller. This 80C51 system presents a menu-driven operating system that includes complete diagnostic and system functions such as user program upload and download, and remains onboard and usable for the life of the product. Size is 5" x 8", I/O signals total 50 (26 I/ 24 O).

A module rack (50-pin header) interface is included, as well as two RS232 connectors, eight-bit analog input, real-time clock, system support for assembled and compiled programs, and an enhanced TinyBASIC interpreter in ROM that has debug, load and save, and I/O commands. All features listed are standard.

A full developer kit with board, manual, supply, serial cable, and software diskette is \$179.00.

For more information, contact:

**INDUSTROLOGIC, INC.**  
3201 HIGHGATE LN., DEPT. NV, ST. CHARLES, MO 63301  
314-707-8818 WEB: [www.industrologic.com](http://www.industrologic.com)

## KENWOOD CS-5300 SERIES ANALOG OSCILLOSCOPES

Products Int'l., Inc. introduces the new CS-5300 series of analog oscilloscopes from Kenwood. These oscilloscopes are available in either 50 MHz or 100 MHz, with or without cursors, and readouts.

The CS-5300 series does not use multi-function knobs. Thus, an inexperienced person may use it easily. Straightforward switch layout on the panel eliminates errors even on complicated operations.

The CS-5300 series also features: Automatic setup of both horizontal and vertical axis (CS-5370/5350), with the models with readout function, waveforms can be displayed in optimum sizes by simply pressing the auto button once.

Automatic measurements of voltage and

frequency (CS-5370/5350), even analog oscilloscopes, these models are capable of measuring the parameters of input signals automatically.

Plus/minus 2% accuracy with both horizontal and vertical axis, all of the four models achieve high measurement accuracy of 2%.

Multi-trace display of any desired channel.

Relay attenuator with improved reliability.

For more information, contact:

**PRODUCTS INT'L, INC.**  
8931 BROOKVILLE RD.  
DEPT. NV  
SILVER SPRING, MD 20910  
301-587-7824 FAX: 301-585-5402  
1-800-638-2020  
E-MAIL: [scott@prodintl.com](mailto:scott@prodintl.com)

## NEW DUAL DISPLAY MULTIMETER

Tenna Test Equipment announces the introduction of their new Model 72-6558 Professional Dual Display True RMS Multimeter, available from MCM Electronics.

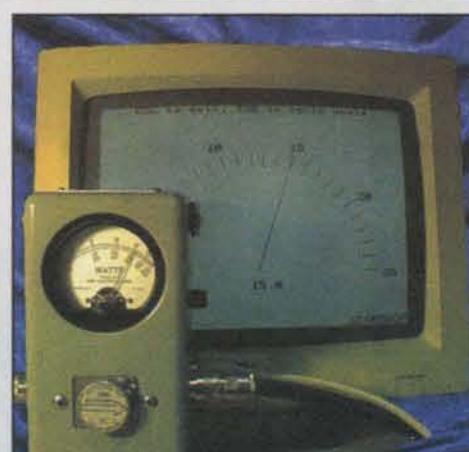
The multimeter's features are: Dual 5-1/2 digit back-lit LCD display with analog bargraph; simultaneous measurement of two different parameters of the same signal; selectable count resolution of 200,000, 20,000, and 2,000; measures AC and DC voltage and current, resistance, frequency, capacitance, and temperature; true RMS AC

and AC+DC measurement; and 1000V maximum DC measurement with 1mV resolution and 0.01% accuracy.

The new model 72-6558 at only \$579.00 also includes an RS-232 interface and can be used in IEEE systems with optional IEEE-488 GPIB interface.

For more information, contact:

**MCM ELECTRONICS**  
650 CONGRESS PARK DR., DEPT. NV, CENTERVILLE, OH 45459  
937-434-0031 FAX: 937-434-6959 1-800-543-4330  
WEB: [www.mcmelectronics.com](http://www.mcmelectronics.com)



## BIRDWATCHER II

Glentech, Inc. introduces the BIRDWATCHER II, the first dial-in remote sensing interface for the Bird Model 43 wattmeter.

The BIRDWATCHER II and included software allows remote RF data access by simply plugging the wattmeter into a telephone line. BIRDWATCHER II software provides a big screen analog and digital remote sensing display from anywhere in the world.

The fully assembled and tested BIRDWATCHER II PC board mounts on the meter terminals of the wattmeter and has two modes of operation. In the bypassed mode, the wattmeter operates in its original configuration without degradation. In the enhanced operation mode, the wattmeter is interfaced with the telephone line allowing for full digital and analog computer screen display of wattmeter measurement and movement.

Supplied with a custom back panel for the Model 43, all modifications are completely reversible.

The BIRDWATCHER II with dial-in telephone interface is priced at \$249.95 and BIRDWATCHER I (serial interface) is priced at \$149.95. Both come fully assembled and tested. For more information, contact:

**GLENTECH, INC.**  
731 W. LUNT AVE., DEPT. NV, SCHAUMBURG, IL 60193  
847-891-2584 FAX: 847-891-2587  
WEB: [www.glenetech-rf.com](http://www.glenetech-rf.com)

## MODEL 12086 FILTER

The model 12086 eliminates harmonic interference at the C-band receive antenna with a low loss of 0.05 dB to the passband (3.7 to 4.2 GHz).

The filter installs between the feedhorn and low-noise amplifier to suppress the band of 5.925 to 6.425 GHz with a minimum rejection of 50 dB. The unit has a VSWR of 1.08:1. Grooved flanges are standard, but other connectors are available upon request.

For more information, contact:

**MICROWAVE FILTER COMPANY, INC.**  
6743 KINNE ST., DEPT. NV  
EAST SYRACUSE, NY 13057  
315-438-4747 FAX: 315-463-1467 1-800-448-1666  
E-MAIL: [mfcsales@microwavefilter.com](mailto:mfcsales@microwavefilter.com)  
WEB: [www.microwavefilter.com](http://www.microwavefilter.com)

# A LICENSE FOR MAKING MONEY

**H**ow would you like to earn \$1,000.00 a day by conducting a couple of ship radio station inspections aboard commercial boats required by law to carry marine radio equipment onboard? While this "make \$1,000.00 a day as a licensed technician" sounds like a sales pitch for a training school, this deal is FOR REAL! The FCC has turned over ship radio inspections to a very limited number of marine electronics technicians who hold the required Global Marine Distress Safety System (GMDSS) maintainer's license, FCC test Element 9.

"Effective July 1, 1998, the Commission (FCC) will no longer be conducting ship (radio) inspections," reports J.R. Zoulek, District Director, Federal Communications Commission, Los Angeles, CA.

"The FCC inspects approximately 1,210 vessels each year. To be in compliance with the current rules that require that all inspections be conducted by the Commission, the FCC has had to hire part-time ship inspectors in remote areas ... to travel great distances to inspect radio stations on US ships. The new rules will relieve the FCC of these manpower and financial burdens, while permitting vessels the more convenient and cost-effective alternative of using FCC-licensed technicians from the private sector for inspections," comments the FCC in a recent news bulletin.

The typical FCC fee for inspecting the radio station of a US vessel transporting more than six passengers for hire was \$320.00, and the average time onboard might be less than an hour. For ocean-going vessels, the fee was \$620.00, and the inspection time might take all morning or it might take all afternoon. But if everything was in order, it might only take a couple of hours!

"And arranging for the old FCC ship radio station inspection required months of pre-planning, scheduling, and pre-payment to the Commission," comments Daniel Freniere, captain of CALIFORNIA RESPONDER, a giant oil spill emergency response vessel out of Port Hueneme, CA. "We think that ship radio inspection privatization will be good for everyone," adds Freniere who holds a marine radio operator's permit (Element 1), as well as the GMDSS radio operator license (Element 7).

## FCC COMMERCIAL RADIO LICENSE ELEMENTS

In 1993, the FCC turned over commercial radio license examinations to the private sector. The commercial radio license testing would operate very much like the amateur and aeronautical testing systems after which it was patterned. The old radiotelephone first class, sec-

ond class, and third class licenses had already been combined into the big general radio operator license 10 years earlier. The marine radio telegraph license was still on the books, but there weren't many applicants going for this outmoded means of communications. The ship radar endorsement was kept active, and the broadcast and aircraft endorsements were dropped.

The FCC ADDED the global marine distress and safety system operator's license for operation of the new satellite-based marine emergency sub-systems and equipment. This license will eventually replace all of the Morse Code operator certificates.

The FCC also added the global marine dis-

**The Federal Communications Commission (FCC) commercial general radiotelephone operator license (GROL) lets you repair and adjust aeronautical and marine radio transmitters. The radar endorsement gives you legal access to fix the microwaves. But the granddaddy of them all — GMDSS maintainer — gets you into a brand new market of ship radio station inspections that the FCC has just privatized ...**

who are not required by GMDSS laws to carry specific pieces of satellite or terrestrial emergency radio equipment onboard. All United

States cargo and other commercial vessels, regardless of their area of operation, are required to be GMDSS compliant by February 1, 1999, if they are over 300 gross tons. Boats carrying more than 12 passengers for hire and operating on international voyages are also required to be GMDSS compliant by this date.

Vessels carrying more than six passengers operating in local waters may not be required to be GMDSS compliant, BUT ARE SUBJECT TO OTHER RADIO AND LICENSING REQUIREMENTS and the operator must hold, as a minimum, a marine radio operator's permit, Element 1. Small com-

mercial vessels and recreational vessels are not required to outfit for GMDSS, but may use this equipment on a voluntary basis without any operator licensing requirements. In other words, pleasure craft may not need this satellite-type equipment, but if there are any adjustments to the two-way radios onboard, they must be made by a licensed technician holding a GROL permit.

The designated GMDSS operator onboard one of the commercial vessels will be required to hold the GMDSS radio operator's license, test Elements 1 and 7. Element 7 is a question pool of 444 multiple-choice questions of which 76 will be on the test. Seventy-five (75) percent passing grade is required, and these test elements tend to be more about procedures with very little super-technical questions on amps, volts, or Ohm's Law. Element 1 is the maritime radio rules and regs. Both question pools can be studied and passed with about two or three weeks of reviewing the question pools.

## THE INSPECTOR'S LICENSE

To cash in on the new lucrative inspection business, you will need to hold written Element 1, rules and regs; written Element 3, the GROL technical element; and Element 9, the GMDSS radio maintainer element, based on a pool of



ress and safety system MAINTAINERS license necessary for the repair, INSPECTION, and maintenance of satellite-based marine emergency sub-systems and equipment.

The natural progression for the study, testing, and starting employment in the marine and aviation market would be to first obtain the general radiotelephone operator license (GROL) with radar endorsement.

### Element 1

Marine radio operator permit (MROP), 24-question, multiple-choice exam on rules & regulations

### Element 3

General radiotelephone operator license (GROL), 76-question exam on basic radio electronics

### Element 8

Ship radar endorsement, 50-question written examination on ship and aviation radar equipment

Successfully passing each of the three elements (Element 1, Element 3, and Element 8) leads the applicant to the important GROL license with radar endorsement. This allows the marine and aviation electronics technician to work on conventional radio and radar equip-



### RADIO INSPECTORS WILL NEED TO BE FAMILIAR WITH GMDSS TERMINALS.

250 questions of which 50 technical questions will be on the test.

It is recommended that applicants first prepare and pass written Elements 1, 3, and radar endorsement, Element 8. These 3 elements can be found in the \$34.95 soft-covered book, *GROL PLUS*, written by Gordon West and available for \$30.00 from Gordon West

**A SPECTRUM CHECK OF A VHF SIGNAL MAY BE PART OF THE RADIO INSPECTION.**

Radio School, 2414 College Drive, Costa Mesa, CA 92626. (Please add \$3.00 for Priority Mail, and I am happy to autograph the book for you!) It contains every question, the four multiple-choice answers, a description of the correct answer and how to solve technical questions mathematically, and is your one big source for getting through your marine radio operator's permit and general radio operator license with radar endorsement in one soft-cover copy.

Testing is offered by private commercial operator license examination managers throughout the country, and there are phone numbers to call to locate an examiner or examination team near you. And you can even call ME if you have technical questions about problem-solving within the book!

But you will need to study and pass the more technical GMDSS MAINTAINER 50-question test. If you would like a complete booklet on all of the GMDSS operator and maintainer test questions, along with the correct answer, send an additional \$10.00 and I'll include them with my *GROL* book!

The FCC reports there are over 4,000 GMDSS licensed operators who have passed the test as of August of this year, but only 850 GMDSS maintainer licenses that could allow the license holder to become a ship radio station inspector.

"The Global Maritime Distress and Safety System (GMDSS) replaces the ship-to-ship safety system that used manual Morse Code with a ship-to-shore safety system that used satellite and automated terrestrial communications systems," comments George Dillon with the FCC in Washington, DC. "The FCC requires specific classes of licenses for the inspection of certain categories of ship radio stations. Inspection of cargo vessels or passenger vessels equipped with GMDSS equipment must be conducted by an FCC-licensed technician holding a GMDSS radio maintainer's license," adds Dillon (Internet address: [gdillon@fcc.gov](mailto:gdillon@fcc.gov)).

The vessel owners and operators most likely have a clear picture on whether or not they require periodic ship radio station inspection. In the past they have been inspected by the FCC, but now they are told the FCC no longer conducts these inspections and they must go to the private sector. And here is where you come in.

If you hold the GMDSS radio maintainer's license, along with the very necessary MROP, GROL, and radar endorsement, not only can you give inspections, but you could also do

technical repairs and adjustments on the spot to bring the vessel up to full compliance. Plus getting the word out that you are the local fixer and inspector is going to be tough unless you are already signed up with a local marine electronics dealer who regularly goes aboard commercial boats to adjust the radio apparatus.

"You might look in the yellow pages under marine radio inspectors," comments the FCC out of a local Southern California office. "Or maybe post notices where they might be read by big ship operators," adds the FCC. I recommend visiting your local marine electronics dealer, and working out a plan where you could offer an inspection if they don't already have a GMDSS radio maintainer on staff.

You should also begin working with the national GMDSS implementation task force.

**Jack Fuechsel, Executive Director  
7425 Elgar Street  
Springfield, VA 22151**

"The national GMDSS implementation task force was chartered by the US Coast Guard to supplement government functions in expediting the implementation of the global maritime distress and safety system now being introduced by the International Maritime Organization (IMO)," comments Captain Fuechsel, Executive Director. "We have written to the Coast Guard Auxiliary and to the US Power Squadrons asking them to incorporate GMDSS and especially VHF-DSC (digital selective calling) in their public education courses. Your readers can find most GMDSS task force information bulletins and other documents on the Coast Guard's Internet web site at <http://www.navcen.uscg.mil/narcomms.htm>," adds Fuechsel.

As more big ship and medium-sized yacht communications go from microphone to keyboard, there will be a greater need for qualified marine electronic technicians with a strong background in satellite and digital communications.

Becoming a ship radio station inspector could earn good financial rewards once the word gets out that you are a competent inspector with the capabilities of offering repairs or board replacements right on the spot. But I would strongly suggest you work closely with a big marine electronics provider so the compulsory-equipped big boat operators will know who to contact for inspections and maintenance. Get started with the GROL Elements 1, 3, and radar endorsement 8. Take these tests in one sitting, and then tackle Elements 7 and 9. Having these licenses could lead to an exciting career in marine electronics and commercial ship radio station inspections. NV

CATEGORY OF VESSEL	MINIMUM CLASS OF FCC LICENSE REQUIRED BY PRIVATE SECTOR TECHNICIAN TO CONDUCT INSPECTION — ONLY ONE LICENSE REQUIRED			
	General Radiotelephone Operator License	GMDSS Radio Maintainer's License	Second Class Radiotelegraph Operator's Certificate	First Class Radiotelegraph Operator's Certificate
Radiotelephone equipped vessels subject to 47 CFR subpart R or S	✓	✓	✓	✓
Radiotelegraph equipped vessels subject to 47 CFR subpart Q			✓	✓
GMDSS equipped vessels subject to 47 CFR subpart W or subpart Q			✓	

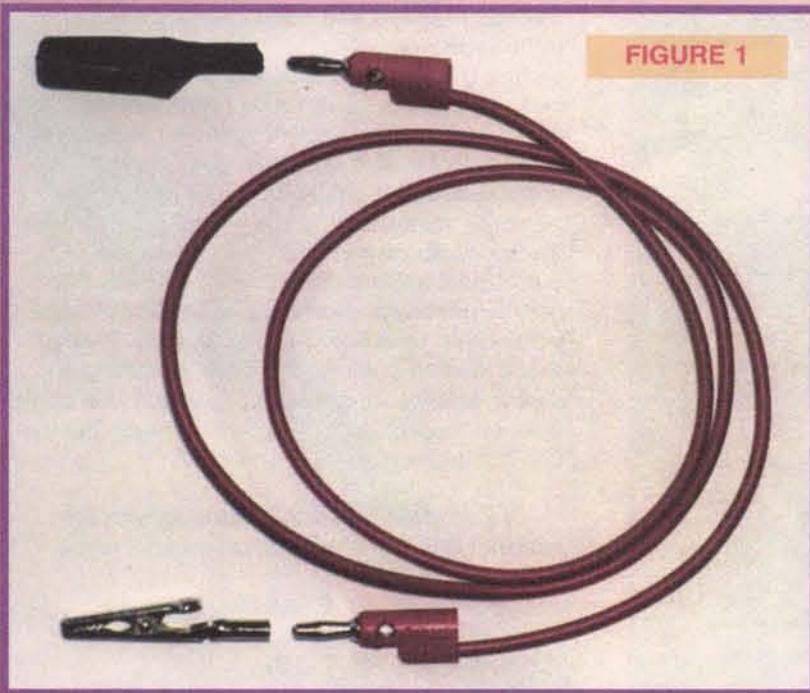


FIGURE 1

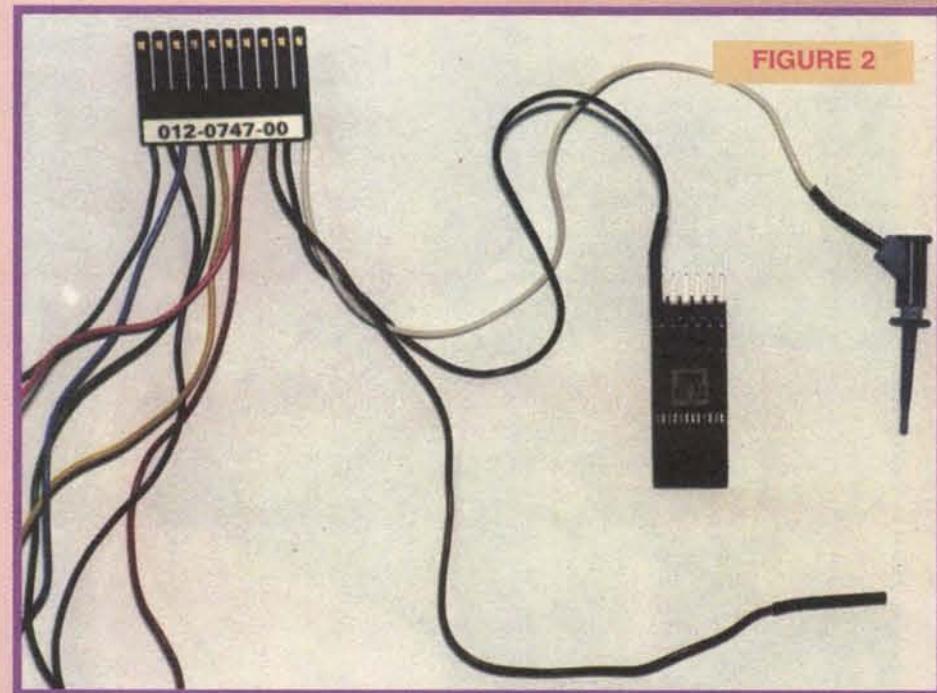


FIGURE 2

## INTRODUCTION

It's pretty hard to get excited about a bunch of low-tech wires, but they are necessary. Using the wrong cables creates clumsy connections that take a long time to make, fall apart when you

supply leads. Some alligator clips and insulating boots turn the patch cords into alligator clip leads.

The middle number in Table 1 is the length in inches, and the last number is the color code (Pomona uses the resistor color code). I have a

lot of them because they mate with ribbon cable headers and the posts on IC test clips (see Figure 2). It's silly to have hooks flopping off an IC test clip. Furthermore, you can get grabbers with 0.025-inch posts to put on the end of these leads — just

# Test Leads

by Gerald Royle

breathe on them, and compromise measurements. Good leads make solid electrical and mechanical connections. A well-equipped lab needs a wide selection of test leads to connect power supplies, signal generators, and oscilloscopes to circuits being tested.

Test leads can be split into two broad categories: single leads (e.g., clip leads) and shielded cables (e.g., coaxial cables). For each category, I will describe what is useful and suggest products. Part numbers and approximate prices are included.

## SINGLE LEADS

Ordinary leads are separate wires that are used to connect power supplies, make DVM measurements, or clip in debugging components such as potentiometers or capacitors. Heavy gauge wire is needed for power supplies and high current measurements, and delicate clips are needed for small components.

### Banana Plugs and Alligator Clips

In the old days, test leads were almost always some combination of pin plugs, banana plugs, and alligator clips. Pin plugs have pretty much disappeared, and instead of having all combinations of banana plugs and alligator clips, it makes more sense to have a collection of banana plug leads and separate alligator clips that slip onto the banana plugs (see Figure 1).

For many years, ITT Pomona has made stackable banana plug leads (Pomona calls them patch cords) that are ideal for this purpose. These patch cords use 18-gauge wire, so they are good power

wide selection of patch cords in several lengths and colors. Short lengths are not used often, but they are good for connecting chassis grounds to isolated supply terminals, for example. To get from an instrument to a prototype needs 24-inch leads if they are on the same surface (e.g., the bench top). Longer leads (36 to 48 inches) are needed to go from a shelf above the table to the bench or from an instrument cart to the table. If the leads are too long, then they tangle and get in the way.

### Hooks and Grabbers

Components are smaller these days, so banana plugs and alligator clips are too large for signal connections. Hooks (also called grabbers) are now more common than alligator clips, and they come in many sizes. Pomona's tradenames are Minigrabber, Micrograbber, and SMD Grabber, and single leads cost from \$4.00 to \$6.00 each.

When I needed several small clip leads, I bought a set of five small, 16-inch hooks (Philmore No. 500, IC Test Leads). The set was cheap (only \$10.00), but it has given me lots of trouble. The leads use solid instead of stranded wire, so the leads are stiff and less reliable. One lead became intermittent when I was tuning some 7th order elliptic filters for a client; that failure cost much more than the whole set. I do not recommend the Philmore leads, but I continue to use it — warily.

Someday soon I will replace the Philmore set with some leads that have sockets for 0.025-inch posts. Most logic analyzer leads use these sock-

ets because they mate with ribbon cable headers and the posts on IC test clips (see Figure 2). It's silly to have hooks flopping off an IC test clip. Furthermore, you can get grabbers with 0.025-inch posts to put on the end of these leads — just

## SHIELDED CABLES AND ADAPTERS

Some labs have huge collections of test leads to cover the wide variety of possible connections: BNC to banana plugs, BNC to hooks, BNC to alligator clips. The enormous variety is due to the profusion of different connectors. If we limit the domain to just RF connectors, then there are the common BNC, TNC, N, F, and SMA families. Add to that list the more exotic RF connectors, such as SMB, SMC, and the ultra-serious APC-7. Older RF equipment needs UHF, GR, and BSM connectors. Having test leads for all possibilities requires a lot of space and is expensive.

The saner approach is to own a selection of standard cables of different lengths and use adapters. My standard cables are BNC male on each end and range from 12 to 60 inches long. BNC cables are an obvious choice because most

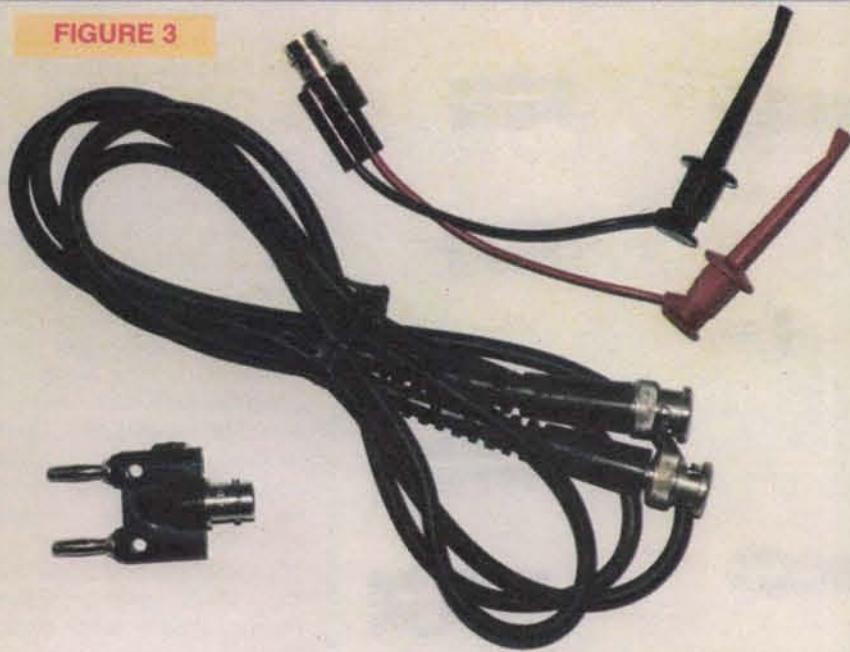
Patch cord, 24in, black	Pomona B-24-0	\$3.70
Patch cord, 24in, red	Pomona B-24-2	\$3.70
Alligator Clips (10 pack)	Pomona 2240	\$6.00

TABLE 1

0.025 inch patch cords Kit of 10	Pomona 4741-6-* Pomona 5948	\$3.55 \$20.90
Micrograbber with 0.025 post Kit of 10	Pomona 4521-* Pomona 5925	\$2.50 \$22.50

TABLE 2

FIGURE 3



of my test equipment uses BNC connectors. BNC connectors are rugged, mate quickly, and have reasonable RF performance. In contrast, F connectors are fragile, take a long time to screw on, and destroy your fingers. Most of my cables are 50-ohm RG-58, but some are RG-174 (thin) or RG-59 (75-ohm).

Standard cables and an array of adapters save money and clutter. An adapter usually costs less than a cable, takes less space, and won't tangle. With a small set of adapters, you can cobble together a cable with unusual connectors, such as an F connector to RCA phonograph plug — something I actually had to do when I connected a folded dipole antenna to a cheap receiver.

#### BNC Cables

Reliability is important, so all my BNC cables have crimp connectors. Clamp connectors are less rugged and more likely to be improperly assembled. At one place I worked, intermittent clamp connectors caused so much grief that any suspicion demanded instant amputation. I would stay away from twist-on connectors for lab work, but I have used twist-on F connectors for TV installations.

#### Buying BNC Cables

Good BNC cables are not expen-

sive. I bought most of my BNC cables at surplus stores. The price is about \$5.00 for a used cable, but I have paid as little as \$2.00. The main features of surplus cables are quality connectors and professional construction. New cables from ITT Pomona Electronics sell for about \$12.00 per cable; the last two digits in Table 3 specify the length in inches.

#### Making BNC Cables

You can make your own cables, but consider the total cost and the reliability. You must make several cables to cover the tooling cost. If your

BNC Cable, 12inch	Pomona 2249-C-12	\$11.75
BNC Cable, 24inch	Pomona 2249-C-24	\$11.75
BNC Cable, 36inch	Pomona 2249-C-36	\$11.75
BNC Cable, 48inch	Pomona 2249-C-48	\$14.65
BNC Cable, 60inch	Pomona 2249-C-60	\$14.65

TABLE 3

assembly skills are poor, then you will end up distrusting the cables and amputating suspect connectors.

A crimp tool with the appropriate die for the coax and connector is a necessity. The better crimp tools have ratchets to guarantee a complete crimp cycle (the military demands ratchets). An Ideal Crimpmaster with one die costs about \$55.00. The Crimpmaster uses interchangeable dies, so it can cover several different cables and connectors. You can buy no-name crimp tools for about \$25.00, but finding additional dies is difficult.

The dies will have at least two cavities. The large cavity is for crimping the braid, and the coax cable determines its size. The smaller cavity is for the center pin, and the connector type determines its size. Crimp tools that don't have a cavity to crimp the center-pin are useless. Crimping the center pin with a pair of pliers is not an option.

#### Ideal Crimp Tools

A cable-stripping tool may be handy, but I have had poor luck with them. I have tried a half dozen different models, but only found one that worked well, and it was for RG8. The others required delicate adjustments, and I spent more time adjusting the stripper than using it. By the way, before stripping a cable, lightly roll the end on the floor with



FIGURE 4

IDEAL CRIMPMaster		Cable	Connector Family	Cavity Sizes
Frame+Die	Die Only			
30-483	30-578	RG6, RG59	BNC and TNC	.324, .255, .068, .042
30-484	30-587	RG58, RG174	BNC and TNC	.213, .178, .068, .042
30-502	30-581	RG58, RG59/62	BNC and TNC	
30-503	30-582	RG6, RG59	F	
30-482	30-577	RG8/11	N	

TABLE 4

Feed-through terminator	Pomona 4119-50	\$45.00
Terminator	Halted #971LB	\$1.49

TABLE 5

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your foot. Rolling the cable makes the end round again — cutting or bending a cable often flattens it and makes the stripper nick the wires.

I strip coax cables with a pocketknife. To avoid nicking the braid or the wire, I don't cut all the way through the insulation, but leave a little that I can pull or twist off.

In addition to the tooling, you need the cable and the connectors. RG-58 coax costs about \$0.15 per foot. Cheap BNC connectors cost about \$1.50, and higher quality connectors range up to \$10.00 each. Common brand names for connectors are Amp, Amphenol, and Kings. Make sure you get all the parts — some distributors sell from bulk packaging, and the stock clerks may miss some important pieces for RG174 connectors.

For RG174 connectors. Also get the assembly instructions, because the strip lengths are important in making a reliable connector.

Buying a quality used cable for \$5.00 is a better deal than making a new one for \$3.50 (plus the cost of tooling), but I do make some of my cables. The market in new and used RG174 cables is very small, so making them from scratch is more attractive. New RG174 cables from Pomona cost \$18.00, so making just a few cables will pay for the crimp tool.

#### Cable-to-Cable Connectors

If you want to connect two cables together,

BNC(f) to N(m)	Mouser 161-9736	\$4.17
BNC(f) to TNC(m)	Mouser 161-9734	\$2.18
BNC(f) to Mini-UHF(m)	Halted #590B	\$2.95
BNC(f) to UHF(m)	Halted #950NPB	\$1.95

TABLE 6

BNC(f) to dual banana plug	Pomona 1269	\$5.80
BNC(m) to dual binding post	Pomona 1296	\$10.75

TABLE 7

BNC(f) to Minigrabber clips	Pomona 3788	\$8.20
BNC(f) to Micrograbber	Pomona 5188	\$10.85
BNC(f) to 0.025 sockets	Pomona 5069	\$8.35

TABLE 8

you need a barrel connector (BNC(f) at both ends). A BNC T connector — female at both ends with a male connector sticking out the side — also works. It compromises the impedance match and the shielding, but the T is useful for high-impedance scope and meter connections.

#### BNC Terminators

You should have some 50-ohm BNC terminators. Many scope inputs are high input impedance, and connecting cables to these inputs causes reflections. A terminator at the input will kill these reflections. Feed-through terminators are best because they minimize stub length, but a 50-ohm terminator attached to a BNC T also works. In desperate times, I've plugged 51-ohm resistors into BNC Ts.

#### Adapters

Adapters allow you to change a BNC cable into almost any other kind of cable. Adapter qual-

ity and price vary widely. Mil-Spec connectors have good finishes and mate smoothly. Unfortunately, they cost \$10.00 to \$50.00 each. At swap meets and surplus stores, you might find them for about \$5.00. Lower quality adapters cost much less and will serve most users.

Going from BNC to some other connector system could require any of four adapters: two connector and two possible sexes create a total of four combinations. We could require a lot of adapters. Fortunately, most coaxial connections follow a convention: the cables use male connectors and the instruments use female connectors. If all parties follow the cable convention and all cables use BNC connectors, then we need only one combination: BNC(f) to Other(m).

We can cover many conversions with a shopping list that adapts BNC(f) to Other(m). Other adapters need more explanation, and are covered later. I usually get at least two of each adapter that I need. I don't have any TNC or mini-UHF adapters because none of my equipment uses those connectors.

#### BNC to Dual Banana Plug

Some of my instruments have dual banana jack inputs. Initially, I attached dual banana plugs to shielded cables, but those cables had several problems. They weren't very rugged, and mechanically attaching the cable to the plug was never pretty — knots and cable ties lack aesthetic appeal.

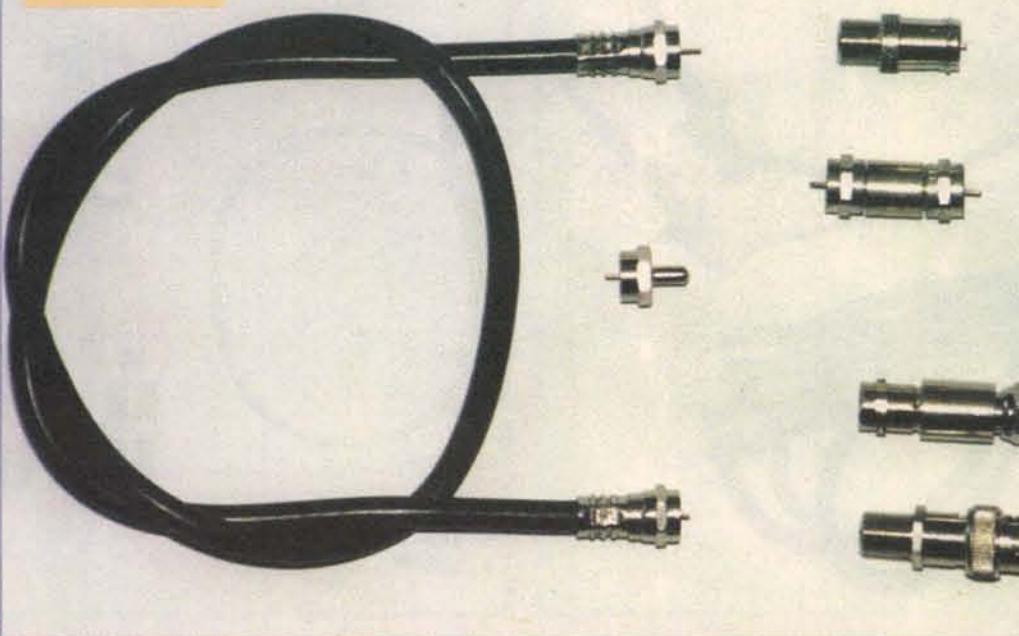
Then I discovered a Pomona 1269 BNC(f) to dual banana plug adapter, and threw away my dual banana plug cables (see Figure 3). The adapter is very rugged, and I use them a lot. A Pomona 1296 is useful for going the other way, but you will use it less often.

#### BNC to Clip Leads

I've seen many ersatz 1X "scope probes" made from coax cable. There's a BNC(m) on one end, and the other end sports soldered-on alligator clips or grabbers. These probes look ugly and are not sturdy. The coax braid is exposed and can short nodes to ground, and the fine wires in the braid fray quickly. The center lead of a coax cable is fragile, so its attachment to the alligator clip breaks easily. The center dielectric is stiff, so the center cable connection is not very pliable.

A better solution — one that avoids the above faults — uses a clip lead adapter at the end of an ordinary BNC cable (Figure 3). I have two Pomona

FIGURE 5



3788 adapters (BNC(f) to six-inch Minigrabber leads), and I use them all the time. I'll use one to supply the output of my function generator to the prototype, and the second to connect my digital voltmeter (DVM).

In fact, I almost always use my DVM with the combination of the Pomona 1269, BNC cable, and Pomona 3788; the only problem is the exposed (uninsulated) BNC connectors. The Minigrabber is easier than using a point probe, and the coax cable avoids tangled probe leads. Pomona also has a Micrograbber version, but the 5069 and separate Micrograbbers is a better plan.

#### BNC to SMA and Friends

For low frequencies, BNC to SMA adapters work okay (see Figure 4), but the conversion from the delicate SMA connector to the larger BNC is mechanically awkward. I often worry that I'm going to break an SMA connector with the lever arm made by the adapter and the BNC cable connector.

For microwave signals, avoid adapters and BNC hardware. Instead, use good cables with SMA connectors. Unfortunately, SMA cables cost a small fortune — \$40.00 to \$50.00 each — and the performance requirements are high enough that you don't want to make them yourself. SMA cables use silver-plated conductors, teflon dielectric, and gold-plated connectors. Instead of buying SMA cables, I bought some microwave hulks and salvaged some cables (and a lot of other stuff in the bargain).

With your SMA cables, you will want some barrel connectors and some BNC(m) to SMA(f) adapters. Although BNC Ts are common, never buy an SMA T.

Some instruments use SMB or SMC connectors, and for these delicate connectors I've thrown in the towel and opted for special-purpose cables (scrounged from microwave hulks or bought from surplus dealers). I have some SMB(m) to BNC(m) cables for my counter, and some SMC(m) to SMA(m) cables for my microwave detectors.

Although there have been several good deals on microwave equipment with hermaphroditic APC-7 connectors, I've shied away because the adapters are too expensive. Used APC-7 to SMA adapters cost about \$70.00.

#### N Connectors

N connectors are high-performance RF connectors that are used in the Gigahertz range. They offer better impedance control than BNC connectors, handle more power, and are often weatherproof. They are found on signal generators and network analyzers.

By the way, the term N connector is short for Navy connector, and the term BNC is short for Bayonet Navy Connector. The connectors are related in more than just name: an N(m) actually mates with a BNC(f). The other combination (which is the one we want) doesn't mate, so you will need some N(m) to BNC(f) adapters.

If your interest is microwave, then you want N(m) to SMA(f) adapters. BNC does not have the performance.

Almost all N connectors are 50-ohm, but 75-ohm N connectors also exist. Unfortunately, they don't look much different, and inadvertently mating them can wreck one of the connectors. There

BNC(f) to SMA(m)	Halted #11335B	\$3.89
BNC(m) to SMA(f)	Halted #11340B	\$3.89

TABLE 9

F(f) to push-on F(m)	Halted #FC62B	0.69
F(f) to F(f) barrel	Halted #FC67B	0.39
F(m) to F(m)	Halted #FC73B	0.89

TABLE 10

BNC(f) to F(m)	Mouser 161-9731	\$2.23
BNC(m) to F(f)	Mouser 161-9733	\$2.21

TABLE 11

BNC(f) to RCA(m)	Halted #957B	\$1.49
BNC(m) to RCA(f)	Halted #955B	\$1.29

TABLE 12

are even precision 75-ohm BNC connectors that should not be mated with 50-ohm BNC connectors.

#### BNC to F Connectors

The overwhelming feature of F connectors is that they are incredibly cheap. The center pin of an F connector is the solid center conductor of the coax cable, and it is easily bent. You must mate the connectors carefully. Their low cost is offset by the time to mate the connectors and the wear and tear on your fingers. If you do any bench testing with F connectors, get some push-on F adapters. These adapters have threaded F(f) on one end

and push-on F(m) on the other. They save time and fingers.

Joining two F-connector cables requires a barrel connector. In some tests, I connect power splitters and directional couplers back-to-back, so F(m) to F(m) adapters are also useful.

F connectors are used in TV systems and imply 75-ohm cable. You will need a collection of 75-ohm (RG59 or RG6) cables. Although all your 75-ohm cables could use F(m) connectors, you will want some BNC 75-ohm cables because BNC connectors are more rugged. TV and cable test equipment use F connectors, but I have yet to see a scope with an F connector. Consequently, you will need two kinds of BNC-F adapters.

The BNC to F adapters don't address the impedance change between 50 and 75 ohms, and sometimes that change is critical. My signal generators, detectors, and oscilloscopes are 50-ohm instruments, so I have a couple of min-loss attenuators to adapt the impedance levels. Sorry, but I don't know an inexpensive source for these parts. When I visit a surplus store, I check the "vegetable drawer" of the Tektronix scope carts for this sort of gold. The store usually gives me a good price for this merchandise they didn't know they had. Twice I have considered buying a scope cart just for the contents of the drawer: once for the connectors and once for the scope manuals.

#### Audio

There is also tremendous variety in audio connectors, and a trip to the local audio store or RadioShack will let you load up on adapters among audio connectors using phone, miniature

phone, subminiature phone, and RCA phonograph varieties. There are also mono and stereo variations of some connectors. Serious users will want some XLR connectors. Pay particular attention to the types of cables: there are speaker cables and microphone cables. The latter cables are shielded for low-level signals.

It doesn't make sense to use BNC cables as the standard in audio work. Instead I use subminiature stereo phone cables as the standard cable. Occasionally, you will want to connect an audio signal to your scope, and about the only common adapter is a BNC to RCA phonograph. I have both directions for this adapter, and have been surprised how often I use them. Many cheap radio and TV tuners use RCA jacks for RF connectors.

Most audio connections are 600 ohm, but the cable impedance is not 600 ohm. Reflections and impedance matching are not usually a problem at audio frequencies because the shortest wavelength is about 15 kilometers. **NV**

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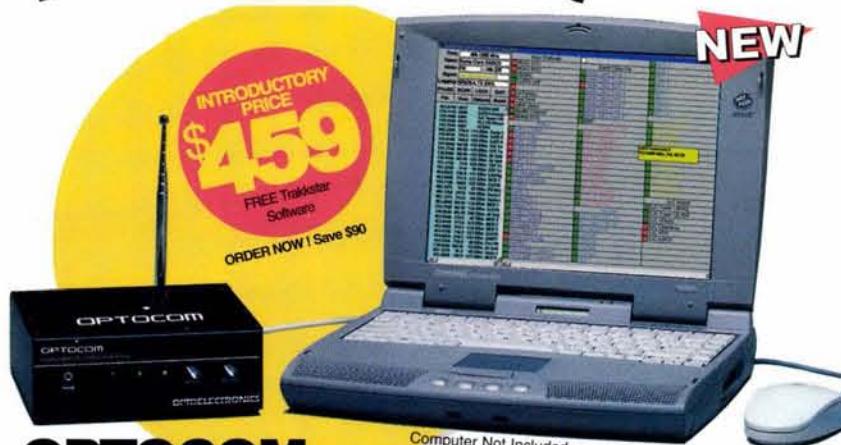
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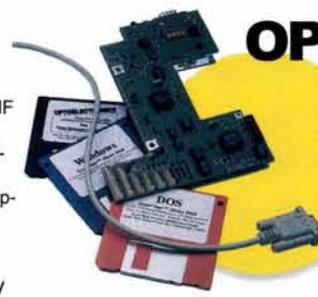
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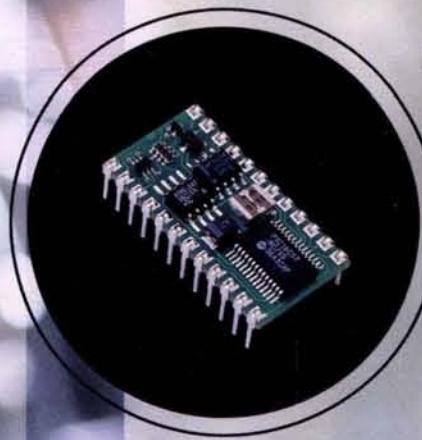
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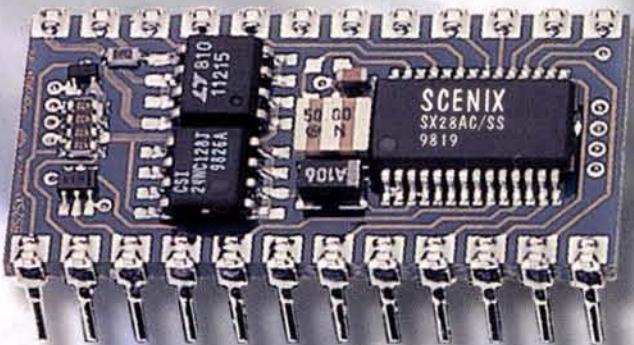
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